Development of Smart City Infrastructure in Barcelona

I.   Introduction

People often think of Smart Cities as the panacea to numerous modern problems such as environmental health, traffic congestion, waste disposal, and energy efficiency. Although many cities are pioneering smart technology projects, Barcelona distinguished itself by successfully completing a multitude. Compared with other cities which experienced notable failures, such as Toronto and its Quayside project with Sidewalk Labs, cities view Barcelona as a model for what other cities can emulate. Some of their pioneering projects include smart bike sharing, smart parking, smart lighting, noise pollution monitoring, and even internet platforms for civic engagement (e-democracy). Large government supported investment in tech sector initiatives and startup incubators drive much of Barcelona's success. This paper therefore seeks to investigate how inclusive Barcelona's smart city programs have been, along with how equitable its benefits have been distributed. To do so, this paper will include a literature review of critical analyses of the Barcelona model of smart city policy then synthesize and discuss its benefits and costs. Specifically, this paper will investigate the process by which the policies have been created, analyze how much access citizens have to smart services, then discuss whether the citizens or private companies stand to benefit from their implementation.

II.   Description of Case

Historical Context

Tuba et al (2013) notes that Barcelona's desire to lead infrastructure projects dates to the 1980s, when it sought to recover from "deep economic crisis" and become a metropolis.[1] Rhetorically,

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[1] Bakici, Tuba, Esteve Almirall, and Jonathan Wareham. "A Smart City Initiative: The Case of Barcelona." *Journal of the Knowledge Economy* 4, no. 2 (June 2013): 135–48. http://dx.doi.org/10.1007/s13132-012-0084-9.

discussions of smart city strategies began in the early 2000s, when the Catalan Socialist Party (PSC) and the red-green party controlled local politics. Practically, it wasn't until Mayor Xavier Trias rose to office in 2011 that Barcelona put rhetoric into action. March et. al (2018) describe this era as the first "generation" of Barcelona's smart city strategy, focused primarily on "self-sufficiency, efficiency, quality of life, and social equity." These initiatives focused on quality of infrastructure in the city, all under one department named the Hábitat Urbá. Barcelona's sought to be a "laboratory for the city of the future," funded primarily through flourishing public private partnerships (PPP). Barcelona initiated many projects, including the creation of a City Operating System (City OS) for managing disparate city data for use, public makerspaces and fabrication laboratories, and smart infrastructures.[2] Angelidou (2014) describes one innovation district that captures the entrepreneurial spirit of this time:

"22@Barcelona District is the most representative case of large-scale urban renewal projects: an innovation district built on 200 ha of formerly brownfield land, equipped with high-technology infrastructure, with the goal of attracting businesses, institutions and other organizations in a climate of openness and cooperation."[3]

Hug et al note that an economic crisis in 2015, along with the shifting of political power to the left-wing political party, Barcelona en Comù, led to smart city policies envisioning a more empowered citizenry, noted as the second "generation" of smart city innovation.[4]

Current Status and Outcomes:

During this second generation, Barcelona pushed many initiatives to increase citizen participation, including a digital participation platform called Decidim Barcelona, ann open-source

[2] March, Hug, and Ramon Ribera-Fumaz. "Barcelona: From Corporate Smart City to Technological Sovereignty." In *Inside Smart Cities*. Routledge, 2018.

[3] Angelidou, Margarita. "*Smart City Policies: A Spatial Approach." Cities*, Current Research on Cities, 41 (July 1, 2014): S3–11. https://doi.org/10.1016/j.cities.2014.06.007.

[4] March, Hug, and Ramon Ribera-Fumaz. "Barcelona: From Corporate Smart City to Technological Sovereignty." In *Inside Smart Cities*. Routledge, 2018.

software used by municipalities, first used in developing an action plan for neighborhood initiatives. Barcelona continues to promote a business-friendly environment, including an incubator called La Comunificadora for "collaborative and sharing economy" projects, hosting start-ups.[5] Barcelona utilizes Sentilo and City OS to provide data for the public's use. Sentilo is an open data source platform connecting all sensors in the city, which is then processed and fed into City OS for citizens to view and utilize. Barcelona puts sustainability and the environmental goals as a priority for urban development. In terms of long term capacity building, businesses, universities, and schools incorporate smart city education and workshops into their curriculum and company practices. [6]

III.   Literature Review

The push for Barcelona to become a leader in smart city policy and innovation parallels the trends in planning thought during the latter half of the 20th century, which notes and analyzes the shift from policies with heavy government involvement from the New Deal era towards business-friendly climates promoting economic growth.

Harvey (1989) discusses the transition from the "managerial" approach cities used in governance, to the "entrepreneurial" approach, emphasizing the value of public private partnerships (PPPs) in promoting infrastructure growth.[7] More recently, Florida (2003) published work on his theory of creative capital, which greatly influenced the way cities crafted policies for economic development. His theory notes that large agglomerations of the "creative class" are responsible for growth in cities, groups that include a wide swath of individuals ranging from scientists and engineers to designers and architects. Florida argues that the creative class brings forth the "3T's" that are ingredients for a city's

[5] Ibid.

[6] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." *Energy Informatics* 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

[7] Harvey, David. "From Managerialism to Entrepreneurialism: The Transformation in Urban Governance in Late Capitalism." *Geografiska Annaler. Series B, Human Geography* 71, no. 1 (1989): 3–17. https://doi.org/10.2307/490503.

success: technology, talent, and tolerance. These members "produce new forms or designs" that directly result in a product for use in society.[8] Echoes of this thought pervade environments by which technological innovation is promoted, notably smart city development, and is therefore important when conceptualizing the push towards smart city policy to attract those within the "creative class."

Greenberg (2008) illustrates these influences in planning on New York, when the City rose from bankruptcy in the 1970s by marketing itself to the world. She notes a shift from a strong government presence to a "climate" more readily inviting to businesses and investments, including ad campaigns to market the City with "financial incentives to promote the city's new climate for business and investment." She notes the desire for New York to "[enhance] its visibility and brand value." She further points to a proportionate concern at the time; Roger Carr, the housing commissioner of New York City at the time, noted that the city "had to ignore the poor…and attract more affluent people."[9] Case studies in cities like New York are important to understand current trends occurring in Barcelona.

While Barcelona's recent policies pushed for smart innovation, authors likewise increasingly published literature critiquing and analyzing Barcelona's approaches. Earlier literature generally applauds Barcelona's model, praising its place as a leader among other cities. Angelidou (2014) notes Barcelona's approach to promoting local-level "soft infrastructure," with a business friendly environment for PPPs to flourish. She praises Barcelona, stating that they place an "outstanding emphasis on human and social capital."[10] In a later paper, however, Angelidou (2017) compares Barcelona to fifteen other cities also seeking to become leaders in smart city policy, and critiques most cities for failing to "incorporate bottom-up approaches…accommodate the local needs of their area, and

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[8] Florida, Richard. "Cities and the Creative Class." *City & Community* 2, no. 1 (2003): 3–19.
[9] Greenberg, Miriam. "New York City as a Symbol of Neoliberalism." In *Branding New York*. Routledge, 2008.
[10] Angelidou, Margarita. "*Smart City Policies: A Spatial Approach." Cities*, Current Research on Cities, 41 (July 1, 2014): S3–11. https://doi.org/10.1016/j.cities.2014.06.007.

consider issues of privacy and security."[11] Likewise, Bakici et. Al (2013) praises Barcelona, noting that

their model "generates…innovation, urban growth, and its citizens' quality of life," while concluding that

it can "provide guidance to practitioners and policymakers of other cities."[12] Angelidou and Bakici's

earlier work emphasize evaluation of policies using neoliberal epistemologies documented by Florida

and Harvey, while largely ignoring discussions of inclusivity, access, and equity.

Authors published more critical literature on Barcelona's smart city model after 2014. Capdevila et

al (2015) provides one of the most critical, discussing smart policy's susceptibility to private interests,

focusing more on the "technology-push than on demand-pull." They further emphasize that local

governments feel pressure to "reinforce their image" and "improve their city branding and international

visibility," which may take the form of city rankings and inevitably lead to comparison of cities that are

"hardly comparable." Capdevila et al conclude by arguing that smart city policy in Barcelona often lacks

consideration of "social/community/human [aspects]".[13] Notably, these critiques come before the

second "generation" of smart city policy, coined by March et al (2018), and therefore analyzed

Barcelona's situation prior to the City's more recent push towards inclusive governance. Likewise,

literature on the strategies of private interests further reinforce this shift. Söderström et al (2014)

critically documents IBM's smarter city campaign to increase "visibility and legitimacy" in the smart city

market, drawing upon strategies rooted in systems thinking and utopianism in corporate storytelling.[14]

The most recent literature discusses Barcelona with an even more critical eye. March et al (2016)

notes Barcelona's well-intentioned policies to tackle issues in sustainable urbanism, though they note

[11] Angelidou, Margarita. "The Role of Smart City Characteristics in the Plans of Fifteen Cities." *Journal of Urban Technology* 24, no. 4 (October 2, 2017): 3–28. https://doi.org/10.1080/10630732.2017.1348880.

[12] Bakici, Tuba, Esteve Almirall, and Jonathan Wareham. "A Smart City Initiative: The Case of Barcelona." *Journal of the Knowledge Economy* 4, no. 2 (June 2013): 135–48. http://dx.doi.org/10.1007/s13132-012-0084-9.

[13] Capdevila, Ignasi, and Matías I. Zarlenga. "Smart City or Smart Citizens? The Barcelona Case." *Journal of Strategy and Management* 8, no. 3 (2015): 266–82. http://dx.doi.org/10.1108/JSMA-03-2015-0030.

[14] Söderström, Ola, Till Paasche, and Francisco Klauser. "Smart Cities as Corporate Storytelling." *City* 18, no. 3 (May 4, 2014): 307–20. https://doi.org/10.1080/13604813.2014.906716.

the risk of reproducing existing inequalities. Notably, they discuss that the new cities channel urban policies through private capital, which results in a procedure that is "[depoliticized]" and pushed out "without much debate" under a guise of sustainability goals while being less inclusive as promised.[15] In a later paper, March et al further note that smart city policy only encompass the "right to use technology" rather than the "right to shape the city," risking to view the democratization of technology as a goal rather than a means of achieving change. They further note that "technological sovereignty" is vaguely defined for many cities, while still being deployed, relying on "overly optimistic" views on digital technology's ability to solve problems beyond its sphere.[16] Lastly, Bibri et al provides a balanced review of Barcelona's model, noting that they are doing well in a number of ways, including citizen participation, transparency of governance, availability of open data, and implementation of smart infrastructure, while simultaneously issuing a warning to not "fall into the trap" of prioritizing a hierarchy of goals that prioritizes social ones the least.[17]

IV.   Discussion

Benefits and Progress

Paralleling Greenberg's (2008) account of New York City, since the 1980s, Barcelona used marketing and branding strategies to respond to economic crisis and increase investment from private companies.[18] Barcelona's business-friendly approach brought global brand awareness via smart city initiatives. Bakici et al (2013) and Angelidou (2014, 2017) tout Barcelona as a model for other cities to emulate.[19] In addition to being featured in scholarly planning literature on smart city policy, Barcelona

[15] March, Hug, and Ramon Riberta-Fumaz. "Smart Contradictions: The Politics of Making Barcelona a Self-Sufficient City," 2016. https://journals-sagepub-com.ezproxy.cul.columbia.edu/doi/full/10.1177/0969776414554488?utm_source=summon&utm_medium=discovery-provider.

[16] March, Hug, and Ramon Ribera-Fumaz. "Barcelona: From Corporate Smart City to Technological Sovereignty." In *Inside Smart Cities*. Routledge, 2018.

[17] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." *Energy Informatics* 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

[18] Greenberg, Miriam. "New York City as a Symbol of Neoliberalism." In *Branding New York*. Routledge, 2008.

[19] Angelidou, Margarita. "*Smart City Policies: A Spatial Approach." Cities*, Current Research on Cities, 41 (July 1, 2014): S3–11. https://doi.org/10.1016/j.cities.2014.06.007.; Angelidou, Margarita. "The Role of Smart City Characteristics in the Plans of Fifteen Cities."

was ranked number four on the Eden Strategy Institute's 2020/2021 Smart City Government Report.[20]

Furthermore, Bibri et al (2020) notes that Barcelona is doing well in several ways including on citizen participation, transparency of governance, availability of open data, and implementation of smart infrastructure, which translated into large cost-savings and positive press. According to Cisco estimates, Barcelona's investments will return cumulative benefits of $970 million by 2026. Smart lights effectively optimize energy consumption by pushing data through the Sentilo Platform for analysis. Sensors optimize traffic flow, and monitor air quality for air quality improvement measures. Although, Bibri et al do not discuss how equitably Barcelona placed sensors across the city, wherever air quality and traffic sensors are placed in the city, the study notes real time data is collected and used to identify areas where urgent action is most needed, which is an equitable deployment of smart services in the subset of the city where sensors are placed.[21]

Relative to fifteen other cities similarly implementing smart city projects, Angelidou (2014) praises Barcelona's ability to crowdsource ideas, noting that generally smart cities have trouble incorporating "bottom-up approaches."[22] Since the second generation of smart city projects began, however, Barcelona's push to involve citizen participation in policy decisions shifted perceptions further positively. Bibri et al (2020) notes that Barcelona is "performing well" when "[involving] citizens in policy decisions and in the development of services" and that the strategy is to "[empower] the citizens." Bibri et al note that agencies make services extremely accessible, since they are offered remotely or through mobile kiosks across the City. Agencies handle data, often touted as "the new oil," in a way that makes it accessible to the public through City OS since 2010. [23] In a push towards equity and inclusivity,

Journal of Urban Technology 24, no. 4 (October 2, 2017): 3–28. https://doi.org/10.1080/10630732.2017.1348880.**;** Bakici, Tuba, Esteve Almirall, and Jonathan Wareham. "A Smart City Initiative: The Case of Barcelona." _Journal of the Knowledge Economy_ 4, no. 2 (June 2013): 135–48. http://dx.doi.org/10.1007/s13132-012-0084-9.

[20] SMART CITY GOVERNMENTS. "2020/21 Publication." Accessed November 11, 2021. https://www.smartcitygovt.com/202021-publication.

[21] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." _Energy Informatics_ 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

[22] Angelidou, Margarita. "_Smart City Policies: A Spatial Approach._" _Cities_, Current Research on Cities, 41 (July 1, 2014): S3–11. https://doi.org/10.1016/j.cities.2014.06.007.

[23] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." _Energy Informatics_ 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

Barcelona's citizen participation platform, Decedim Barcelona, pushed forward municipal proposals where 40,000 people proposed, deliberated, and voted on what should be done in each neighborhood, along with more recent plans such as Pla Clima (Barcelona's climate action plan) and other discussions requiring public deliberation.[24] Barcelona is further "one of the very few cities" where educational programs focus on incorporating big data analytics disciplines in universities and business schools. These educational efforts have the potential make smart services and technical knowledge more readily accessible to the public.

Generally, media coverage leans positive. In an article written in Wired, Francesca Bria, Barcelona's Chief Technology and Digital Innovation Officer, notes that data privacy is at the core of smart city policy. She notes that "citizens can decide what kind of data they want to keep private, what data they want to share, with whom, on what basis, and to do what" while noting further that this is akin to "a new deal on data." Two pilot programs seek to further empower citizens, including "giving residents sensors to place in their neighborhoods" to be integrated with Sentilo. This way, citizens completely own their data to improve public services in an approach the article note as a "very modern form of volunteering."[25]

Cautions

However, warnings from planning literature echo in Barcelona's case as well. Often in modern city planning, cities returning from economic distress place significant emphasis on business-friendly environments to attract investment. These attitudes reflect both the shift towards "entrepreneurial" governance that Harvey (1989) noted, and a catering to the "creative class" that Florida (2003)

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[24] March, Hug, and Ramon Ribera-Fumaz. "Barcelona: From Corporate Smart City to Technological Sovereignty." In *Inside Smart Cities*. Routledge, 2018.
[25] "Barcelona Is Leading the Fightback against Smart City Surveillance." *Wired UK*. Accessed December 17, 2021. https://www.wired.co.uk/article/barcelona-decidim-ada-colau-francesca-bria-decode.

documented in his theory of creative capital.[26] [27] Particularly, Harvey notes the emphasis on urban

entrepreneurialism should leave people wary of too large of a focus on "investment and economic

development" that is often speculative rather than one that focuses on the "amelioration of conditions."

March et al. (2018) further elaborates on the speculative nature of urban entrepreneurialism.

They note these initiatives can often be "vaguely defined," "overly optimistic," while relying too heavily

on technology to solve problems beyond the "technology sphere." Their study raises an important issue

that in Barcelona, reflective discourse on smart city initiatives generally encompasses the notion of

"right to use technology" rather than the notion of "right to shape the city." Ultimately, March et al

conclude that the democratization of technology should be a "tool to pursue progressive and

emancipatory urban transformation" rather than an "end goal."[28]

Like New York, Barcelona pushed forward with innovation, progress, and entrepreneurialism

only to ignore very real social issues driving the need for innovation in the first place. Bibri et al (2020)

note that in the name of sustainability and environmentalism, social issues tend to take a back seat.

Although they note the challenges when tackling a multitude of issues in smart policy, they conclude

that Barcelona must do better and develop a "broader agenda entailing an amalgam of environmental,

economic, and social concerns."[29] Barcelona's recent push to promote its global brand led to adverse

effects on its local population in the form of rising rents and gentrification. Journalists note that

Barcelona "acted on its historic center to make it attractive to tourists."[30] Kotsila et al note changes in

demographics within Ciutat Vella (Old City), which experienced a 13% drop in households with children

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[26] Harvey, David. "From Managerialism to Entrepreneurialism: The Transformation in Urban Governance in Late Capitalism." *Geografiska Annaler. Series B, Human Geography* 71, no. 1 (1989): 3–17. https://doi.org/10.2307/490503.

[27] Florida, Richard. "Cities and the Creative Class." *City & Community* 2, no. 1 (2003): 3–19.

[28] March, Hug, and Ramon Ribera-Fumaz. "Barcelona: From Corporate Smart City to Technological Sovereignty." In *Inside Smart Cities*. Routledge, 2018.

[29] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." *Energy Informatics* 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

[30] Llimós, Albert. "Barcelona, Caught between the Middle Class and Inequality." Ara in English, March 12, 2021. https://en.ara.cat/society/barcelona-caught-between-the-middle-class-and-inequality_130_3899682.html.

from 2007 to 2016, which coincided with large increases of Airbnb units due to the trends in "green

livability." They argue that tourist gentrification is "driven by capital flows, market changes, and land

speculation," causing residents to be displaced to peripheral neighborhoods.[31]

March et al (2016) further warns of private capital's influence in undertaking problems in urban

sustainability. They warn that the process often has been "[depoliticized]" while smart services are

"produced and handed out…without much debate, all for the sake of having a so-called more

sustainable city. " They further warn of smart city strategies reproducing existing inequalities due to "big

tech companies searching for business opportunities" while "not being as inclusive as they promise."

Ultimately, March et al (2016) urges the repoliticization of the debate over technological solutions,

rather than allowing silent accumulation of capital.[32]

Another area for concern is internet access in the city and cybersecurity, which directly affects

citizens' ability to utilize smart services. Bibri et al (2020) succinctly summarizes smart city cyber risks in

Barcelona as follows:

"Most of the smart city strategies fall short in considering risks…can be attributed to the ambiguities in

government laws and the lack of institutional and organizational policies" [33]

Security risks are paramount when considering equity since the distribution of risk for internet

connected technologies (ICTs) affects different stakeholders differently. Private companies often

possess significant resources, including investors and other sources of wealth and connections to

weather the negative consequences of security threats. Members of frontline communities, however,

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[31] Anguelovski, Isabelle, and James J. T. Connolly, eds. *The Green City and Social Injustice: 21 Tales from North America and Europe*. Routledge Equity, Justice and the Sustainable City. Abingdon, Oxon ; New York, NY: Routledge, 2022.

[32] March, Hug, and Ramon Riberta-Fumaz. "Smart Contradictions: The Politics of Making Barcelona a Self-Sufficient City," 2016. https://journals-sagepub-com.ezproxy.cul.columbia.edu/doi/full/10.1177/0969776414554488?utm_source=summon&utm_medium=discovery-provider.

[33] Bibri, Simon Elias, and John Krogstie. "The Emerging Data–Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona." *Energy Informatics* 3, no. 1 (June 26, 2020): 5. https://doi.org/10.1186/s42162-020-00108-6.

do not possess wealth and therefore may not be readily able to recover. Bibri et al (2020) noted that

70% of households had internet access, and 65% coverage of mobile data in the city, noting that this is

an area Barcelona seeks to improve considerably in the future.[34] Because access to the internet is the

foundation to participating in many smart city initiatives, development will be inherently unequal until

its network is continually built out to service more of the citizenry.

V.   Conclusion

Ultimately, Barcelona is unquestionably a leader in pioneering smart city initiatives within its city

compared to other cities worldwide. However, Barcelona's pushes to advancing smart city policy results

in complicated outcomes since its benefits are not guaranteed to be distributed equitably and often

leads to gentrification and rising rents. Further research on its policy evolution must be conducted to

understand to what extent citizens voices are incorporated in shaping their democratic processes, since

internet access is not comprehensive. Recent pushes to incorporate citizen participation and smart city

education are promising and allow citizens to enjoy efficient services through its sensor networks.

Barcelona's current progressive political government signals well-intentioned policy goals. However,

because Barcelona's smart city strategy still relies on the PPP model, there will be a continued tension

between private interests and public well-being. Overall, their approach will need to be continually

reexamined to ensure citizens are prioritized instead of leveraged to increase the city's brand image.

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[34] Ibid.

VI.   Appendix

SMART CITY GOVERNMENTS. "2020/21 Publication." Accessed November 11, 2021.
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Angelidou, Margarita. "Smart City Policies: A Spatial Approach." *Cities*, Current Research on Cities, 41 (July 1, 2014): S3–11. https://doi.org/10.1016/j.cities.2014.06.007.

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March, Hug, and Ramon Riberta-Fumaz. "Smart Contradictions: The Politics of Making Barcelona a Self-Sufficient City," 2016. https://journals-sagepub-com.ezproxy.cul.columbia.edu/doi/full/10.1177/0969776414554488?utm_source=summon&utm_medium=discovery-provider.

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