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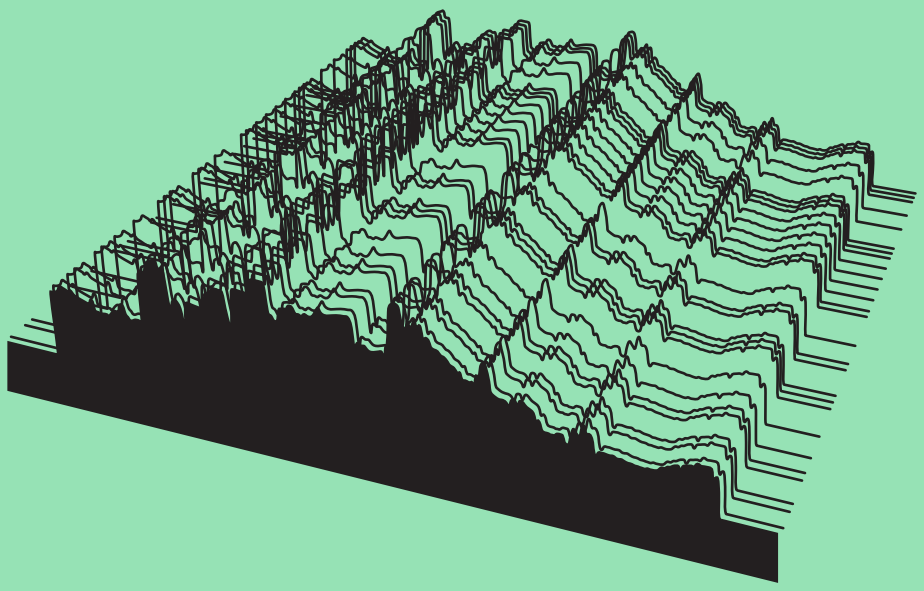
# The Circular City

## Research Journal

Vol. I



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# The Circular City

Research Journal

Vol. 1

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Dear Reader,

The Circular City introduces a new way of rendering a city “smart.”

Intelligence is measured by agility, collaboration, and the ability to use technology to meet real needs. You'll read more about those needs, partnerships, and the conditions necessary to scale this nimble approach in the following pages, but first I wanted to share with you where this all began.

A lot of what's seen today feels like technology for technology’s sake. Pilots come and go without clear benefit to communities, our public institutions, and the private sector. In fact, often these entities are at odds with one another; they lack incentives to collaborate, and, in many cases, are denied the forums to do so even if they wanted to. For technology to really work for a city, though, it's essential that it works for all these different stakeholders. Urban technologies cannot scale when they haven't been proven, and they can't be proven without the right collaborators at the table.

When a pilot or a call to action unfolds without a mindset shift and commitment to the agile methodologies that make iteration, market fit, and scale happen, it falls flat—the effort reaches the end of the line and there's no way for it to grow or to apply the lessons learned, to move more quickly or gain more traction.

New Lab wanted to change that. We wanted to create an infrastructure of collaboration: a leaner way to ask questions of our city and to empower entrepreneurs to build and deploy the technologies best suited to answer those questions. In doing so, the “smart cities” products that align with real needs could be rewarded and scaled, and we could act with intention and speed.

That is what The Circular City is about. Over the last year we've run a grand experiment to see if we could turn a set of stakeholders—start-ups, civic leaders, corporate partners, and university innovators—toward one another, in an effort to create a feedback loop and set of collaborations. These new feedback loops will inform further experiments. These collaborators will help us seed new partnerships. Together, we’ll make progress in the cross-sector, iterative and intentional way that change has always worked best in cities.

Our hypothesis was that these stakeholders could have far greater impact if they were motivated to collaborate in service of the biggest challenges facing us today and given the platform to do so. If we provided our stakeholders permission to build, test, and iterate new approaches and new products, we could generate a virtuous cycle whereby new ideas, new technologies, new challenges, and new partners create a new paradigm of smart cities. Ultimately, we believe this is what’s needed to push the market forward—and perhaps, in the process, human experience, too!

The *Research Journal* is a central component of The Circular City. For the first time, New Lab has brought together a consortium of scholars, guided by André Corrêa d'Almeida’s ARCx - Applied Research for Change, to conduct applied research. This work is significant; the *Journal* is creating a

framework to quantify and document our experiments, our progress, the lessons learned, and the conditions that will be required to scale this work in a meaningful way.

I'm thrilled and humbled by the results we've seen in this initial “grand experiment.” None of it would have been possible without our partners; to each of them we are grateful. I invite you to get to know them in the course of the research presented here. As you take a closer look, I hope you'll see the blueprint that's emerging and the clear opportunity we have in front of us to evolve this work in pursuit of The Circular City.

Sincerely,

Shaina Horowitz
Urban Tech Hub Director, New Lab

# Contents

# Introduction to The Circular City Research Program

André Corrêa d'Almeida, *Columbia University and ARCx - Applied Research for Change*

Urban centers have traditionally been a source of economic opportunity. During the industrial revolution, people relocated to cities to escape the isolation of rural living, incentivized by industry-specific hubs and the lure of employment. In 2016, according to U.S. Census data, rural areas comprised 97 percent of land in the United States but only housed 19.3 percent of the total population. On a global scale, today 55 percent of the world's population lives in urban areas, with an anticipated increase to 70 percent by 2050.

The strain many cities are experiencing on systems, infrastructure, and transportation is a reflection of this growth. While cities are adapting to burgeoning populations, both public and private sectors are seeing increased opportunities to harness emerging technologies and big data to prepare cities for a sustainable future. In Brooklyn, the potential for such collaboration to have a positive impact inspired the 2018 launch of The Circular City program to focus on three urban challenges: economic growth, urban mobility, and urban resilience.

This inaugural edition of New Lab's Research Journal (i) describes the process of developing and launching New Lab's The Circular City program, (ii) introduces circular city data as the first exploration of this program, and (iii) investigates and methodologically tests the value of circular data applied to three urban challenges: economic development, mobility, and resilience. The research program was developed by ARCx - Applied Research for Change for and with New Lab, between January 2018 and March 2019, with the collaboration of scholars from the School of International and Public Affairs and The Earth Institute at Columbia University, The Governance Lab (GovLab) at New York University, and Cornell Tech.

ARCx - Applied Research for Change is a research consortium founded by André Corrêa d'Almeida in 2015 while spearheading his Columbia University Press book *Smarter New York City: How City Agencies Innovate* (2018). Originally comprised of 30 leading scholars from 10 different universities and 22 research centers, ARCx focuses on studying and building innovation networks in the U.S. and around the world.

More specifically, coming out of ten months of applied, participatory, and multidisciplinary research, this journal presents:

A. One case study developed to document and explain how the program was conceived, designed, and implemented, with the goal of offering lessons for scalability at New Lab and replicability in other cities around the world. The key questions explored in the case study are:
    a. What is The Circular City?
    b. What is Circular City Data?

c. How might we build, scale-up, and replicate a circular city data program for smarter economic development, mobility, and resilience and sustainability?

B. Three research papers developed to investigate three urban challenges:
   a. What is the value of this program for economic development in New York City?
   b. What is the value of this program for mobility in New York City?
   c. What is the value of this program for resilience and sustainability in New York City?
   d. What are the conditions of success for this value creation?
   e. What are the risks and the corresponding mitigation strategies?

In the course of this program we are introducing new terms alongside new collaborators. Therefore, before diving into each paper, it is important to establish shared definitions and fully introduce the series of collaborators who will be discussed throughout.

### 1. New Lab

In a repurposed shipbuilding warehouse in the Brooklyn Navy Yard sits New Lab, a company on a mission to help scale frontier technologies. New Lab is home to a growing network of tech start-ups, including over 100 companies, and an ecosystem of government and corporate partners. Officially opened in 2016, New Lab now holds a massive brain trust and an even larger network of partners, enabling a highly collaborative environment built for entrepreneurs, by entrepreneurs. New Lab's start-ups include hardware-focused, tech-manufacturing, growth-stage companies working in the fields of robotics, connected devices, energy, and urban tech, to name a few. While a private, for-profit company, New Lab's DNA consists of a public-private partnership, one where investment and collaboration between the public and private sectors is seen not only as important, but necessary. On Wednesday, May 23, 2018, David Belt, Founder and CEO of New Lab, brought together Eric Adams, Brooklyn Borough President, Sander Dolder, Vice President of NYC's Economic Development Corporation (EDC), Regina Myer, President of the Downtown Brooklyn Partnership (DBP), Shaina Horowitz, New Lab's Urban Tech Hub Director, and André Corrêa d'Almeida, of Columbia University and founder of ARCx - Applied Research for Change, to publicly launch The Circular City program.

### 2. Key Stakeholders and Collaborators: a public-private partnership

While the case study explains in detail the evolution of New Lab's The Circular City program and each of the stakeholders that joined, plus their rationale for joining, expectations, goals, and risks faced, this introduction describes one specific category of players that is repeatedly mentioned in the papers and is the subject of the applied research agenda explored in each paper: start-ups. New Lab recruited three start-ups to take part in the first year of The Circular City program; each was selected for its unique relationship to city-scale data.

CARMERA

A street-level intelligence platform for autonomous mobility and part of the initial cohort of companies taking part in New Lab's Urban Tech program. CARMERA's flagship product, CARMERA Autonomous

Map, is a real-time high definition mapping suite. Nearly all AV programs today rely on these HD maps as a critical gating factor in helping answer the three core questions AV brains are constantly asking: Where am I? What's around me? Where should I go next? CARMERA is solving this problem by combining LiDAR/RGB data for semantic base mapping with a camera-only change-detection layer. CARMERA's three products:

- Autonomous Map: an HD mapping suite gathers real-time navigation-critical data for autonomous vehicles, allowing them to know where they are, confirm what they're seeing, and know where to go next.
- Site Intelligence: spatial data and street analytics, including block-level pedestrian analytics, historical trend data, 3D/vector models, and more.
- Fleet Monitoring: a visual telematics service for high-coverage fleets such as delivery trucks, using powerful but inexpensive roof-mounted sensors. CARMERA provides fleet professionals with real-time telematics and video monitoring to offer state-of-the-art safety, cost management, liability protection, and driver efficiency technology in exchange for the placement of sensors and cameras on fleet vehicles to collect data.

### Numina

A stand-alone sensor and data platform that uses computer vision to measure the volumes, movements, and interactions of cyclists, pedestrians, vehicles of all classes, and other travelers and objects (wheelchairs, strollers, street furniture, trash bags, and more) in streets and public spaces. Numina's measurements of *what*, *where*, *when*, and *how* things move in cities help transportation planners, mobility companies, and other stakeholders design better urban systems for people rather than for cars. Numina's sensors mount to light poles and capture images multiple times per second with a simple visible-spectrum camera. The sensors process all raw data (imagery) onboard each device and then discard the images to protect citizen privacy, sending only anonymous metadata (object classes, counts, locations, and timestamps) every minute via cellular network. New detection and analysis capabilities are continually uploaded to the system over-the-air as they are developed. Additional insights are computed in the cloud and delivered to users via a web dashboard and an API—effectively making Numina a system to turn city streets into a developer platform. Numina is the only computer vision-based sensing platform in the market that was purpose-built from Day 1 to provide street-level *intelligence without surveillance*.

### Citiesense

A graduate of the Urban-X Program focused on making local neighborhood-level data more accessible. Unlike the other start-ups, Citiesense does not collect or sell data itself at this time. Rather, it sells access to a knowledge-management platform that enables place-based community organizations and their members to establish a valuable knowledge base for data about their neighborhood. The platform achieves this goal by centralizing the tools used to track local data, improving how the neighborhood performs by better managing community assets, whether public or privately owned. This includes a wide

range of local data sets, such as data about local businesses, real estate development, available commercial space, streets, and parks, as well as local events and services.

The team behind Citiesense embraces the belief that local communities know their neighborhood the best and are the most invested in its future, yet lack technical tools and methods to organize their collective knowledge into actionable data that can be used to create the best future. Citiesense aims to solve this problem with the platform's collaborative map-based data toolkit, eventually enabling local communities to license access to their local data through existing community-membership revenue models.

Tables 1-3 provide additional information about each start-up, including size of the company, mission statement, types of data produced and/or collected, customers, users, and beneficiaries.

**Table 1:** Start-ups' Mission Statements

| Name | Established | #Employees | Funding | Mission Statement |
|---|---|---|---|---|
| **CARMERA** | 2015 | Around 40 | $27.1M | To provide real-time HD maps and navigation-critical data to autonomous vehicles. |
| **Numina** | 2016 | Around 10 | $2M | To empower cities with data to become more responsive and equitable. |
| **Citiesense** | 2015 | 3 Founders | $150K | To make data accessible at the local level for neighborhood stakeholders and the groups they work with. |

In order to understand better the unique relationship of each start-up to city-scale data, Table 2 offers a data framework that describes six different data typologies used by the firms in varying degrees:

1. **Raw data**, also known as primary data, is data directly collected from a source. Raw data has not been subjected to processing, "cleaning" by researchers to remove outliers, obvious instrument reading errors or data entry errors, or any analysis.
2. **Processed data** is data that has been processed from raw data where processing may include cleaning, aggregation, conversion to a different format, etc.
3. **Combined data** is data that is the result of bringing together multiple data sources, e.g., pedestrian count and weather data.
4. **Data Sold to Customers** is data packaged as a data set the customer can download or packaged as a service the customer can query via an API. In both cases (data set and API), the data is contingent on a fee and the customer also expects a service level agreement in terms of quality, freshness, etc.

5. **Data Given In-Kind** is the same as Data Sold to Customer with no contractual obligations in terms of quality, freshness, etc. The data is often given "as is."
6. **Usage Data** is data about how users consume the data. In the context of web data and Google, the data is information about the Web (pages, content of pages, etc.) and usage data is the popularity of pages based on queries.

**Table 2:** Start-ups' Data Frameworks and Typologies

| Type of Data | CARMERA | Numina | Citiesense |
|---|---|---|---|
| **Raw Data** | Video footage from its fleet camera and LiDAR data, which can be processed to provide:<br>- Pedestrian Analytics<br>- Street-Level Still Images<br>- Fixed-Street Asset Locations | Object tracks collected from sensors, where each track consists of a unique object category (e.g., pedestrian, bicyclists, car) and a sequence of time-stamped positions. This data can be extracted and aggregated to provide:<br>- Pedestrian Analytics<br>- Street-Level Still Images<br>- Vehicle Movements | The company does not sell data. They sell access to their knowledge management platform for neighborhood communities. The platform enables place-based community organizations and their members to create a valuable knowledge-base for data, such as:<br>- Fixed-Street Asset Locations & Observed Conditions<br>- Businesses, Attractions, Events, Commercial Space Usage, & Development Activity |
| **Processed Data** | Extracted features from video footage to build 3-D maps | Data extracted and aggregated from sensors | - |
| **Combined Data** | - | - | Citiesense product (map platform) |
| **Data Sold to Customers** | Autonomous 3D maps | Detailed count (time series) of objects from sensors | Access to Citiesense product |
| **Data Given In-Kind** | Reports derived from raw data e.g., pedestrian analytics | - | - |
| **Usage Data** | - | - | Queries performed by users in the platform |

Table 3 describes the demand side of start-ups' data.

**Table 3:** Customers, Users, and Beneficiaries

| | **Customers** (Paying for and therefore owning the data/service) | **Users** (Using the data/service) | **Beneficiaries** (Benefiting from the data/service) |
|---|---|---|---|
| **CARMERA** | AV companies | AV manufacturer, AV fleets | Riders, Cities deploying AVs |
| **Numina** | City, Local Development Corporation (LDC), Business Improvement District (BID) | Same as customers + Data enthusiasts if data made open | Residents, Small and mid-size businesses (SMBs), City agencies |
| **Citiesense** | City, LDC, BID | Same as customers + local community members (property owners and SMBs) | SMBs, Real-estate developers, City Agencies |

## 3. The Circular City

The Circular City is the application to urban systems, urban tech in particular, of principles from the circular economy school of thought. According to principles of the circular economy, products can be "made to be made again" through reuse, repair, remanufacture, or recycling—the technical cycle—and food and biologically-based materials can be "designed to feed back into the system" to provide renewable resources for the economy through processes like composting and anaerobic digestion—the biological cycle (Ellen Macarthur Foundation, 2018). Overall, this school of thought aims at building a restorative economy for long-term resilience, business and economic opportunities, and environmental and societal benefits.

Since data and knowledge are quasi-nonphysical, The Circular City takes the principles of finding new value and reducing the waste of physical goods to the realm of the digital with data as the "good" in circulation.

New Lab's The Circular City program is a first-of-its-kind experiment to test whether collaboration between the public and private sector can be intentionally designed to build trust, reciprocity, and a shared vision of public and private good capable of making cities smarter and defining a more resilient, sustainable future for cities.

New Lab's The Circular City program is an infrastructure for collective learning: a virtuous cycle of public-private collaboration whereby new ideas, new challenges, and new partners are introduced to accelerate innovation and rapidly develop, test, evaluate, and scale new technology in order to address urban challenges, and push the smart-cities market forward and positively impact the quality of life in cities.

## 4. Circular City Data

Circular City Data is the topic being explored in the first iteration of New Lab's The Circular City program, which looks at data and knowledge as the energy, flow, and medium of collaboration. Circular data refers to the collection, production, and exchange of data, and business insights, between a series of collaborators around a shared set of inquiries. In some scenarios, data may be produced by start-ups and of high value to the city; in other cases, data may be produced by the city and of potential value to the public, start-ups, or enterprise companies. The conditions that need to be in place to safely, ethically, and efficiently extrapolate the highest potential value from data are what this program aims to uncover.

Similar to living systems, urban systems can be enhanced if the total pool of data available, i.e., energy, can be democratized and decentralized and data analytics used widely to positively impact quality of life. The abundance of data available, the vast differences in capacity across organizations to handle it, and the growing complexity of urban challenges provides an opportunity to test how principles of circular city data can help establish new forms of public and private partnerships that make cities more economically prosperous, livable, and resilient. Though we talk of an overabundance of data, it is often still not visible or tactically wielded at the local level in a way that benefits people.

Circular City Data is an effort to build a safe environment whereby start-ups, city agencies, and larger firms can collect, produce, access and exchange data, as well as business insights, through transaction mechanisms that do not necessarily require currency, i.e., through reciprocity. Circular data is data that travels across a number of stakeholders, helping to deliver insights and make clearer the opportunities where such stakeholders can work together to improve outcomes. It includes cases where a set of "circular" relationships need to be in place in order to produce such data and business insights. For example, if an AI company lacks access to raw data from the city, they won't be able to provide valuable insights to the city. Or, Numina required an established relationship with the DBP in order to access infrastructure necessary for them to install their product and begin generating data that could be shared back with them.

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Next, the case study documents and explains how The Circular City program was conceived, designed, and implemented, with the goal of offering lessons for scalability at New Lab and replicability in other cities around the world. The three papers that follow investigate and methodologically test the value of circular data applied to three different, but related, urban challenges: economic growth, mobility, and resilience. At the end, the conclusion offers a meta-analysis of the value of circular city data for the future of cities and presents, integrated, the tools developed in each paper that can be used for implementation and scaling-up of a circular city program.

André Corrêa d'Almeida, Ph.D.
Research Director for The Circular City program

## References

Corrêa d'Almeida, André ed. 2018. *Smarter New York City: How City Agencies Innovate*. New York: Columbia University Press. https://cup.columbia.edu/book/smarter-new-york-city/9780231183758.

Ellen Macarthur Foundation. 2018. “Concept.” https://www.ellenmacarthurfoundation.org/circular-economy/concept.

# The Circular City Program: The Case Study

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## Summary

On Wednesday, May 23, 2018, after almost a year and a half of preparation, New Lab held an event to publicly launch The Circular City program. The central focus of the program was to bring together several highly strategic stakeholders, including start-ups, scholars from prestigious academic institutions, industry experts, private businesses, civic leaders, and city agencies, to harness emerging technology to tackle the city's most pressing urban challenges. This case study describes how The Circular City program was idealized, designed, and implemented to operationalize, experiment, and test at the local level the promises of circularity, while focusing on three key aspects: (i) New Lab's unique position to take on this initiative, (ii) the importance and role of public-private partnerships and the need to reimagine these partnerships, and (iii) the quest to find the value of circular data as a medium for collaboration and circularity. The abundance of data available, which continues to grow with the introduction of new technologies and analytics capabilities, the vast differences in capacity across organizations to handle it, and the growing complexity of urban challenges provided a unique opportunity to test how principles of circular data can help new forms of public-private partnerships make cities more economically prosperous, livable, and resilient. Ultimately, this case study describes the applied research process of The Circular City program, an iterative and interactive 10-month multi-stakeholder collaboration to assess the value and risks of circular data in an effort to address key urban issues in New York City (NYC).

## Key Takeaways

- New Lab's unique position is highly valuable. New Lab was built by exceptional entrepreneurs for passionate and competitive entrepreneurs, with a focus on supporting growth-stage frontier-technology companies in order to build scalable products and services. With its robust network of strategic partners across NYC, New Lab is able to provide an open-minded and creative outlet where innovation is created with intention and an expectation of experimentation, making this program a safe and trustworthy place for value-driven, lasting collaboration.

- Establishing the value of circular data is difficult. Data is valued differently based on a number of factors, including the type of data and who and what the data is for. This is indicative of the challenges to scaling The Circular City model.

- Public-private partnerships are the essence of The Circular City. Intention, access, and ethics need to be at the center of the program, but without a focus on value added for stakeholders the model will fail to scale in a sustainable way. The Circular City is not merely a partnership between start-ups, the city, and academia; it also includes the important spoke of business and enterprise.

- Data is not fundamental to a circular city program, but the experimentation and specific tests run in New Lab's The Circular City program support the hypothesis that circular data is a highly valuable medium of collaboration for the common good, i.e., private and public. Data is of high interest because it drives business creation and provision of public services, it is an element of resiliency, mobility, and economic growth, and it represents new revenue generation

opportunities. However, not enough consideration has been given to all the ways it will be generated, operationalized, and wielded as the Internet of Things (IoT), artificial intelligence (AI), and mobile devices continue to proliferate. The promise of abundant data is only as powerful as the analytical tools available to people and organizations to create shared value from it.

- Leadership is vital for a collaboration of this nature and size. Managing expectations, ensuring needs are met, mobilizing the right type of highly motivated talent, and developing proper communication and feedback channels is crucial to forming meaningful partnerships. It is essential that the leadership understands the value of creating safe "sandbox" environments that foster experimentation, rapid iteration, and collective learning.

## I. New Lab: The Role of Leadership and Institutions

The Circular City was borne out of a partnership between New Lab and New York City's Economic Development Corporation (EDC), a non-profit corporation focused on economic growth in the five boroughs of NYC. New Lab and EDC first came together under the Urbantech NYC initiative, when in early 2016 New Lab won a request for proposal (RFP) consisting of a $2.5 million, five-year contract from EDC. The aim of the contract was to support the growth of the urban tech sector in NYC and safeguard NYC as an attractive and viable place to build tech products and scale businesses designed to improve quality of life in cities. As New Lab and EDC began working together, it became clear that there were additional opportunities to carry out this intention and support start-ups, including partnerships and pilot opportunities that could help start-ups scale in a bigger way. EDC and New Lab began to conceptualize what improved collaboration between start-ups and the city itself could look like.

In early 2017 New Lab hired Shaina Horowitz to bring the newly designated Urbantech NYC initiative to life at New Lab. Horowitz's role was to design programs for entrepreneurs working to make cities more sustainable and resilient; her focus included  a vibrant and connected community of entrepreneurs and touchpoints with the city, the private sector, and relevant domain experts. The Urban Tech Hub at New Lab, in conjunction with the EDC, had a vision of a community with robust opportunities for collaboration, experimentation, and feedback. The question remained: How could the momentum of the EDC's initial investment be used to push this work forward in a meaningful way?

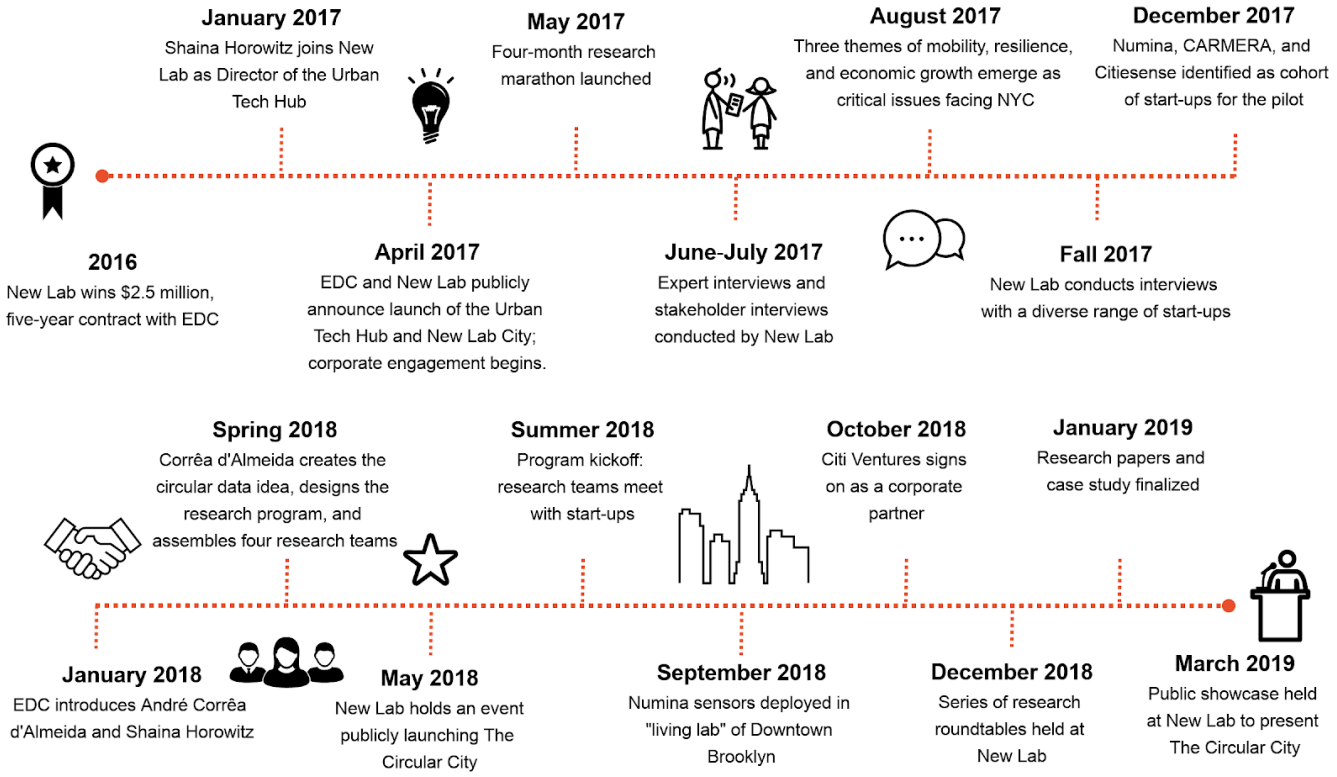
In her first months on the job Horowitz heard a persistent need from entrepreneurs: in order for technologies to scale effectively within cities they needed to be proven to meet real needs and designed to work for a range of stakeholders. Entrepreneurs were struggling to find the right opportunities to test and deploy their products. Even when pilots were secured they often lacked the buy-in from stakeholders who could help them take their product to the next level. Further, pilot opportunities weren't attached to ongoing research and development efforts, meaning learnings and feedback couldn't be meaningfully integrated by entrepreneurs or city stakeholders. In these needs the New Lab team recognized a unique opportunity to serve as the platform to overcome these hurdles and accelerate development, deployment, and partnerships necessary to achieve breakthroughs in how emerging technology can positively impact life in cities.

New Lab was in a unique position to lead the initiative for a few reasons. First, New Lab would be able to quickly select and enroll the most suitable companies for the program. This was important because New Lab was able to fast-track the start-ups' participation. Instead of an open-call process New Lab was able to carefully select which companies would be best suited for the collaboration. If the City of New York ran the pilot, for example, an RFP would be necessary, but New Lab had the benefit of having city stakeholders at the table without the need for an open-call process. Second, New Lab's platform brought together multiple stakeholders—civic leaders, start-ups, academia, and corporate partners— which enabled the program to be built bottom-up at the neighborhood level. Additionally, New Lab was seasoned in supporting start-ups and entrepreneurs, and understood the importance of a start-up's ability to pilot its technology. This was significant because piloting is difficult for urban tech companies (especially in NYC) due to the often bureaucratic systems associated with city partnerships and the use of urban space. However, New Lab's partnership with EDC and their strong ties with the Downtown Brooklyn Partnership (DBP) and the City of New York allowed the amount of red tape to be minimized. For example, Numina was able to install their sensors on DBP-owned infrastructure, rather than infrastructure owned by NYC, enabling an easier deployment (more on that later).

New Lab knows that supporting entrepreneurs is done best when start-ups have access to peers and the opportunity to experiment, and they are constantly working to lower the barriers to doing this. Collaboration and access are essential to the success of growth-stage companies. "Most tech companies are building technologies from a lab," says Horowitz. "The more opportunities they have to pilot their technologies and get feedback from people the better the product will be." An example of this success is JUMP, an electric-bike-sharing start-up working out of New Lab that became the first acquisition of Dara Khosrowshahi, Chief Executive Officer of Uber, in April 2018. JUMP was reported to be acquired for well over $100 million (Newcomer 2018).

When start-ups have the opportunity to pursue provocative experimentation with the lens of commercialization and scale, the sky's the limit. And so The Circular City idea, housed at New Lab, began to take shape. Now, New Lab would need to engage partners to join the effort and a program uniquely suited to their assets, resources, and market position. Figure 1 below summarizes the timeline and main milestones of The Circular City program.

**Figure 1:** Program Timeline and Milestones




## II. The Engagement of Partners: Creating a Circular Collaborative Model

Resiliency, mobility, and economic growth were revealed as the most urgent priority areas in NYC after New Lab conducted interviews with stakeholders who collectively represent thousands of citizens and hundreds of service providers. Among those interviewed were some of the biggest names in NYC urban planning, such as EDC, DBP, the Brooklyn Borough President's Office (BBP), the Mayor's Office of Tech & Innovation (MOTI; since rebranded as MOCTO), Brooklyn Navy Yard Development Corporation (BNYDC), and NYCHA and the Fund for Public Housing. Interviewees were asked to list what they thought the most significant urban challenges facing Brooklyn were, and were later asked to prioritize one issue. Among the answers received were education, diversity, accessibility, employment and unemployment, infrastructure, climate change, connectivity, transportation, and air quality. New Lab concluded from these interviews that the most pressing issues were resiliency and sustainability, mobility, and economic development and that the first iteration of its new program would take these sub-topics as a jumping-off point.

Once priority areas were identified, New Lab began the process of carefully selecting partners for their new initiative. It was clear to New Lab from the outset that public-private partnerships would be central to testing a circular collaborative model. The Circular City would involve a robust network of stakeholders, including growth-stage tech start-ups, large corporations, civic leaders, and academic institutions. The operational definition of "circular"—what and why—had yet to be conceptualized.

## A. Stakeholders

### *Civic Leaders*

One of the first relationships formed, in the Spring of 2017, was between the Downtown Brooklyn Partnership and New Lab. The Downtown Brooklyn Partnership (DBP) is a non-profit local development corporation (LDC) whose goal is to improve the neighborhood of Downtown Brooklyn through business, culture, education, housing, and retail (Downtown Brooklyn Partnership, n.d.). DBP presides over three business improvement districts (BIDs), making it one of the largest and most influential LDCs in New York City. Additionally, Downtown Brooklyn represents a microcosm of what is happening in growing cities around the globe, creating a real-world testing ground for pilots like The Circular City. Downtown Brooklyn is also one of America's fastest growing downtowns, with a population growth of 31%, business growth of 27%, and job growth of 26% (with a 115% growth in tech, media, and advertising jobs alone!) (Downtown Brooklyn Partnership 2019).

DBP was an obvious choice for partnership, as it had worked in varying capacities with New Lab in the past, and its efforts to turn Downtown Brooklyn into a living lab aligned well with what The Circular City was looking for in a partner. DBP provided a real-life space, outside of a conventional lab, in which tech companies could deploy and pilot their technologies. Further, amidst a time of unprecedented growth and development, DBP understood that technology could be used to address some of the challenges Downtown Brooklyn faced.

### *Start-ups*

With DBP on board, New Lab began the process of finding the best start-ups for the collaboration. Using existing relationships within the New Lab community and working with trusted advisors, New Lab conducted interviews with a diverse range of start-ups focused on urban tech—about 20 in total. Start-ups who were producing or analyzing data relevant to urban issues were the primary focus.

Ultimately, New Lab decided to move forward with three start-ups: Numina, CARMERA, and Citiesense.

CARMERA was an obvious fit for the program. The company was already a member of the Urban Tech Hub Program and had worked closely with New Lab to produce its flagship CARMERA Autonomous Map, an HD semantic map of the Brooklyn Navy Yard campus that readied the campus for autonomous vehicle testing. They also outfitted the Navy Yard's fleet of maintenance vehicles with roof-mounted vehicle sensors. This process established a strong relationship between CARMERA and New Lab. For CARMERA, The Circular City program represented a low-risk opportunity because it did not need to develop a special product for the program. By contributing its "data exhaust," CARMERA could tap into the brain-trust of the program and explore new city-level use cases for the data it generates as a by-product of keeping its core HD mapping product up-to-date with street-level conditions. New Lab was comfortable bringing on board a start-up they had previously worked with.

Citiesense, the youngest of the three start-ups, is an NYC-based tech start-up, which had recently emerged from Urban-X, an accelerator with a focus on reimagining city life, and had been part of the Urban Tech program at Grand Central Tech. Starling Childs, Co-Founder and CEO of Citiesense, was immediately excited about the tone of The Circular City program. With the program, Citiesense, who had spent most of their energies thus far developing their platform, would now have a structure in place to test their product. Conveniently, DBP was already a client of Citiesense, and New Lab approached Citiesense to deploy its platform as a community resource. It was a win-win for all involved, so much so that Childs referred to it as a "no-strings-attached" situation and questioned why Citiesense wouldn't entertain the idea, implying Citiesense would have been foolish to pass up the opportunity.

Numina was a contender for The Circular City since the early stages of the program's development. At the time New Lab reached out to Numina, the company was participating in 500 Startups, a California-based early-stage venture fund and seed accelerator for start-ups. New Lab felt that Numina's technology, sensors that provide real-time data of street traffic, were a very strong product fit for the program. However, joining the pilot presented a higher risk for Numina than the other start-ups. Numina was involved in active pilot programs not only in California but across the United States. The start-up had a serious appetite for the program, but didn't want to sign-on to a pilot less than six months long and wanted assurance the program would build strategic relationships and exposure for their company. Numina felt that its data would be most valuable if it were able to analyze it over a longer period of time, and its product requires the installation of hardware and time-consuming calibration of its system. Six months was longer than New Lab had envisioned for the program, but it ultimately agreed to the six-month pilot because it saw great value in Numina as a partner. Tara Pham, Co-Founder and CEO of Numina, felt that "the opportunity to learn and work with other companies in a safe space was very important," as well as knowing they had researchers to document everything.

### *Academia*

While The Circular City was gaining momentum from new partnerships with DBP and start-ups, it became clear that a set of learning and analysis would need to take part alongside technology development and deployment to ultimately deliver on the vision of a "circular" model. This is when, at the suggestion of EDC, New Lab engaged André Corrêa d'Almeida, an Adjunct Associate Professor at Columbia University's School of International Public Affairs and Founder of a new research consortium, ARCx - Applied Research for Change. A development economist scholar himself, Corrêa d'Almeida was asked to conceptualize and operationalize "circularity" and lead the research arm of The Circular City program. Corrêa d'Almeida was able to leverage an existing network that he had originally formed in 2015 while spearheading his book *Smarter New York City: How City Agencies Innovate* (Corrêa d'Almeida 2018). Corrêa d'Almeida's academic work, experience in building innovation networks, and his ability to tap into a large consortium of leading city-wide scholars made him an attractive partner for the program and allowed New Lab to move quickly without having to coordinate with multiple universities.

Through his already-robust network, Corrêa d'Almeida formed a team of high-profile academics from Columbia University's Earth Institute (Nilda Mesa), Cornell Tech (Arnaud Sahuguet), and New York University's GovLab (Stefaan Verhulst and Andrew Young), specializing in what was considered to be

New York City's most pressing issues of resiliency, mobility, and economic development, respectively. The research teams had the support of two Columbia University graduate students from the School of International and Public Affairs' Master of Public Administration in Development Practice program, Caroline McHeffey and Usman Rana. Andrew J. Zahuranec, a research fellow at the GovLab, also contributed to the study. As part of the program, researchers received the opportunity to be in residence at New Lab, providing them with a large network of connections and a real-world working environment in which they could collaborate.

### *City Agencies*

The engagement of city agencies was an important aspect of the Circular City program and one that mainly fell in the hands of the research teams, in close coordination with New Lab. Among the city agencies that participated were NYC's Department of Transportation (DOT), NYC's Economic Development Corporation (EDC), the Department of Information Technology and Telecommunications, the Mayor's Office of Data Analytics, the Mayor's Office of the Chief Technology Officer, the Department of City Planning, the Department of Small Business Services, the Department of Consumer Affairs, the Department of Buildings, the Department of Sanitation, and the Department of Environmental Protection.

### *Corporate Partnerships*

Among the initial challenges of the program was the absence of a corporate partner, which New Lab had envisioned for the program from the start, but the absence didn't last long. In October 2018 Citi Ventures, Citigroup's global corporate venture arm, signed on as the first corporate partner for the program in hopes of laying the foundation for a deeper partnership with New Lab in 2019. Within Citi Ventures lies the "Ventures Studio," which acts as an incubator for Citi Ventures. The studio works to develop products and services in an effort to improve economic vitality for cities, and the people and businesses within them. Citi Ventures joining the pilot was an exciting development, as the Citi Ventures Studio and New Lab had well-aligned visions for how technology will inform the future of cities and shared a particular interest in piloting and commercializing emerging technologies and delivering innovation at scale. In exchange for access to the researchers and start-ups driving the program's activities and the opportunity to work with New Lab to create a shared vision for how to build, launch, and scale urban technologies, Citi Ventures provided funding for The Circular City and great promise for scale-up in 2019. Valla Vakili, the Director and Head of the Ventures Studio, and his four-person team hit the ground running and eagerly engaged with the pilot. Citi Ventures felt that The Circular City, particularly the data-sharing aspect of the program, "enables creating more powerful products and offerings for clients."

Figures 2 and 3 as follow illustrate The Circular City network of key stakeholders.

**Figure 2:** The Circular City Program Network: Introductions and Dynamics of Partnership Creation

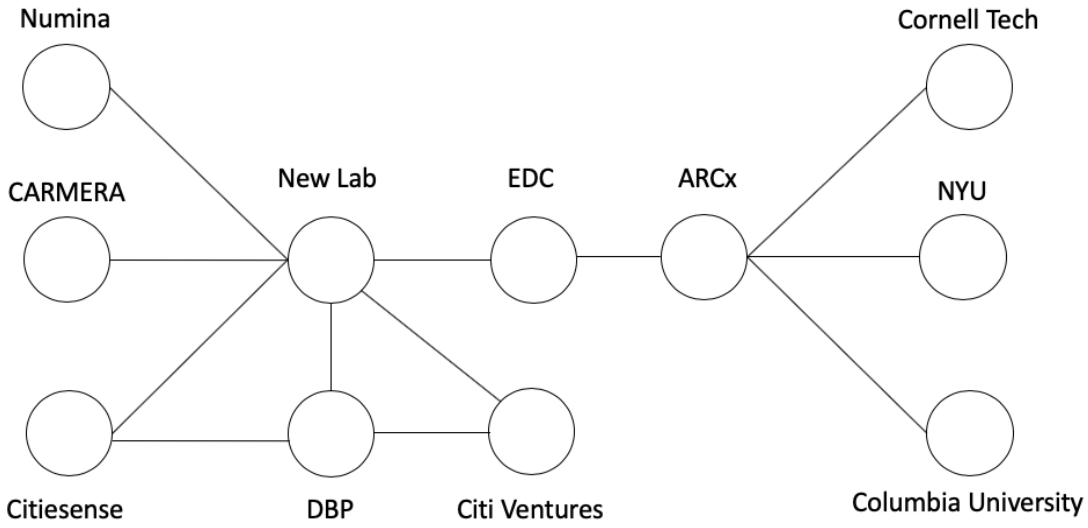
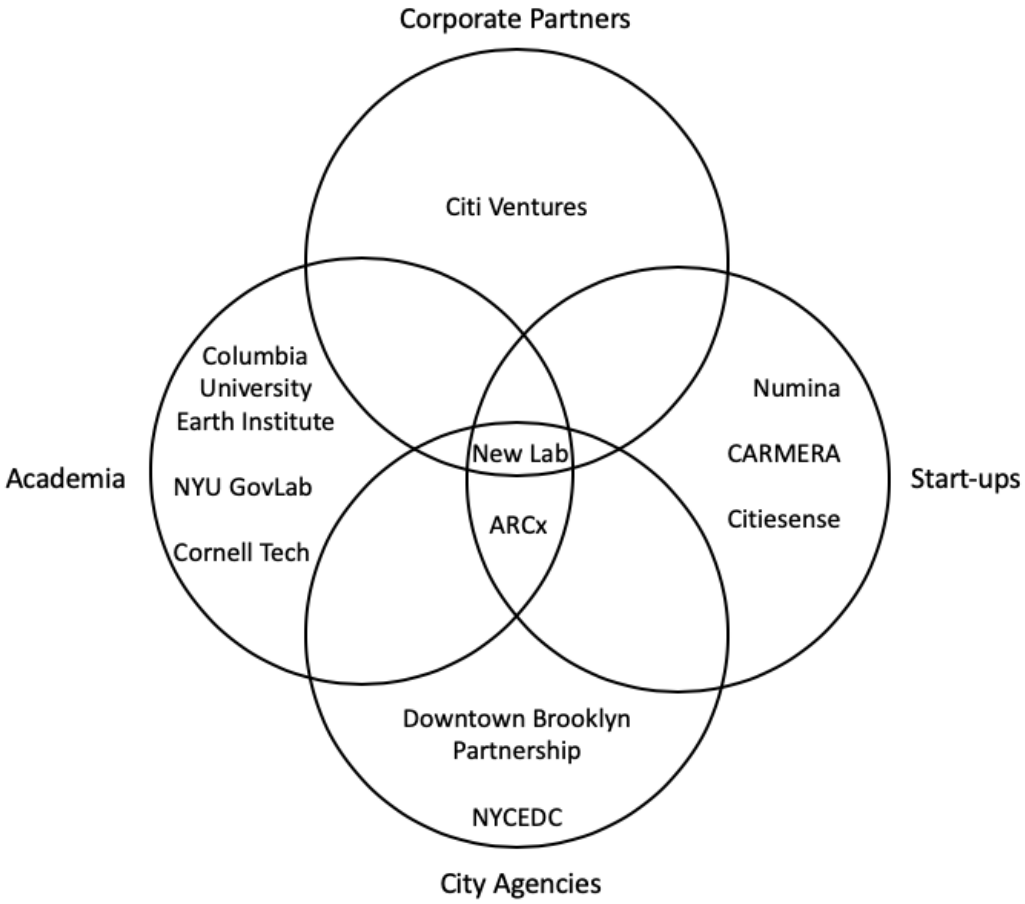



**Figure 3:** The Circular City Program Network: A Model of City-Wide Public-Private Partnerships



## B. Incentives

The Circular City program offered many incentives, although incentives for joining the collaboration differed between stakeholders and sectors. For example, DBP was eager to join The Circular City in part for the opportunity to collaborate with tech companies in exchange for data. In fact, DBP has seen costs savings from similar interventions in the past: after installing Big Belly trash cans in its district, DBP saved hundreds of thousands of dollars due to the data collected by the Big Bellys. Data is of high value to an entity like DBP; not only does it provide cost savings, but it also provides information on quality of life to help improve services in its neighborhood.

For start-ups, participation in the program granted the highly-valued opportunity to pilot their technology in the “living lab” of Downtown Brooklyn, especially for start-ups like Numina. Tara Pham, Founder and CEO of Numina, had moved the start-up from St. Louis to NYC in part because NYC is a hub where urban tech thrives, but the City of New York also has a reputation for being the most difficult municipality to work with. “To be able to start working in New York is a really big deal,” says Pham, who sees the opportunity to work with NYC and DBP as one of the most valuable incentives.

As part of the program, New Lab invited the start-ups to join New Lab. Citiesense and Numina, who were not members of New Lab at the time, were offered in-kind New Lab membership for the duration of the program, providing them with connections to stakeholders, potential corporate partnerships, and the valuable opportunity to pilot their product. Additionally, New Lab offered different services based on the start-up’s specific needs, such as helping to source additional talent or assisting with technical specs during the pilot deployment. It was essential to New Lab that the start-ups felt the program was valuable and would help advance the start-ups’ own goals and business development efforts in the long run. Other incentives for the start-ups included positive public exposure and marketing opportunities, a gesture of goodwill towards the city, out-of-the-box thinking from academia, the potential to expand their customer base, new-use cases for their data, and eventually scale-up and the potential construction of a circular-data platform and other tools in 2019.

CARMERA in particular was eager to find specific use cases for data it generates in the process of creating and maintaining its HD mapping product and hoped that data-sharing agreements with fellow start-ups in the program, DBP, and relevant city agencies could be established. In addition, CARMERA saw great value in partnering with entities such as Cornell Tech and Citiesense, both of which have experience creating data visualization tools. This was an opportunity for CARMERA to use The Circular City program to evaluate Citiesense as a potential front-end visualization partner. After all, CARMERA creates HD maps for autonomous vehicle customers and doesn't offer consumer-facing data visualization tools. While a data-sharing agreement with a stakeholder like DBP would be an ideal outcome for CARMERA, it would need a visualization partner for that data to have maximum impact for a customer, like DBP, with limited capacity to ingest and interpret minimally-processed data sets.

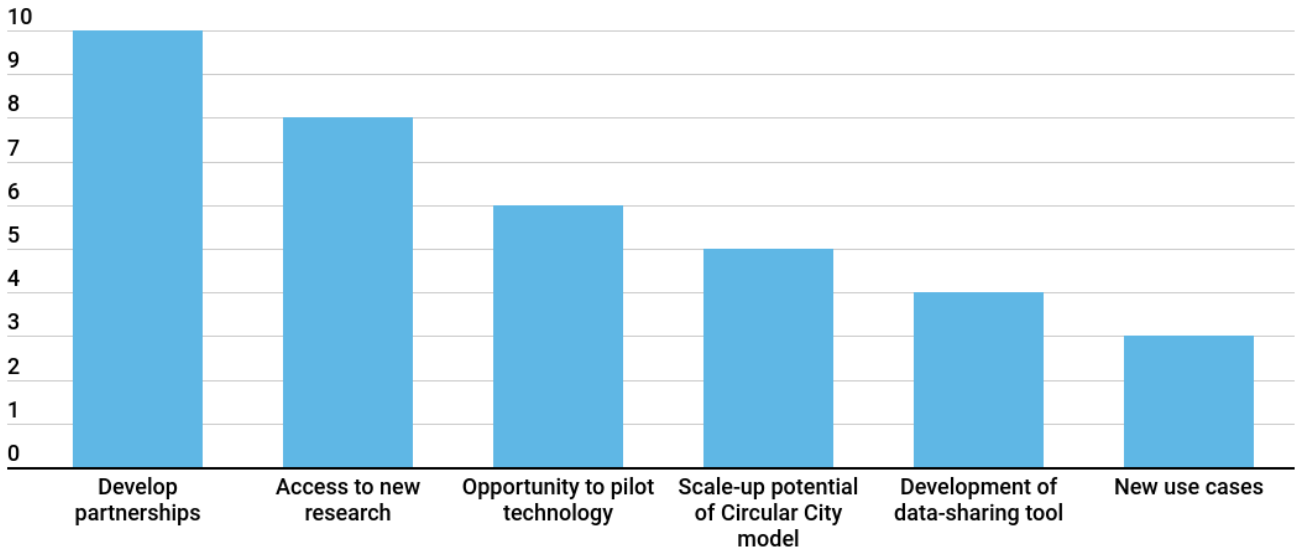
Academics were eager to join the program for access to new data and the opportunity to produce original and impactful applied research, in addition to receiving a small grant for their work. For others, the most important expectations were the scaling-up of the Circular model and producing high-quality

research. Citiesense, for example, saw great importance in inventing solutions that can be scaled. EDC, also wanting to scale the model, needed proof that this type of collaboration works in order to transition from pilot mode to a more robust program on a larger scale. For EDC, this “proof” would be in the form of the research papers showcasing that The Circular City truly represented a new model of open innovation complete with outcomes that grow the urban tech sector in New York.

However, it was generally agreed upon that the greatest collective incentive for all stakeholders was the opportunity for partnerships across business sectors and city domains. Connections to universities could help start-ups find new talent for interns or future hires and allowed access to research that could positively impact the value of their businesses.

In addition to incentives, participants naturally had some concerns about joining the program as well. Everyone agreed that circular data offered immense potential value, but the path to value materialization was less clear. Questions around the usability of data shared, quantification of the intrinsic value of circular data, and how data would be shared had to be explored throughout the program. There were ongoing discussions about what the end deliverable of the first year of the program would look like. One idea was to make a front-end data tool so circular data in a first experimentation could be easily analyzed and understood. Who would develop it, though? One stakeholder noted that cities often don’t use data that they didn’t collect themselves, which led to another question: Who is the data for? In its early stages, there was an air of uncertainty about which direction the program should take. Most of the organizations had not worked with each other in the past, and, to an extent, took a leap of faith in joining such a unique program. Despite having some uncertainty, all of the stakeholders were adamant that the potential benefits of the program greatly outweighed the risks. Soon after the program kicked off, a series of interviews ensued to gain an understanding of the expectations and risks each stakeholder had about joining the program. From these interviews Figure 4 below was developed, illustrating the most commonly cited incentives from stakeholders on joining The Circular City program (each stakeholder listed more than one reason).

**Figure 4:** Stakeholders' Reasons for Joining The Circular City Program




A comprehensive perspective of the incentives and perceived risks reported by each stakeholder can be viewed below in Table 1.

**Table 1:** The Circular City Program: Incentives and Risks

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **New Lab** | -New Lab launched this program to bring together its entire ecosystem to change the way new technology is tested and deployed in cities.<br><br>-New Lab strives to be a neutral multi-stakeholder platform that creates the conditions to experiment, collaborate, and, ultimately, responsibly scale frontier technologies to positively impact life in cities, and this program was one of the first opportunities to realize that mission fully. | -Never-before-done program whose success is tied to the engagement of multiple stakeholders who are not used to working closely.<br><br>-Limited amount of time to design, implement, and show results<br><br>-Bring world-renowned scholars under a unified program vision and research agenda<br><br>-Limited time to mobilize the proper funding to get the program off the ground and to develop a sustainable funding model | -New Lab is interested in using its position as a neutral platform to create "sandbox environments" where new collaborators can share proprietary data and/or assets as they experiment with the value and potential of such collaborations. They're most concerned with facilitating data sharing as a means to fostering product development that solves real problems.<br><br>-Believe more rapid, safe data sharing could help experiments fail faster—it can reveal areas of promise that could then be developed further and more quickly identify areas that are not worth pursuing. |

**Table 1:** The Circular City Program: Incentives and Risks *(continued)*

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **EDC** | -Develop innovative programming that furthers the development and growth of start-ups<br><br>-Foster a cohesive ecosystem that brings together academia, start-ups, corporates, and government<br><br>-Build upon the success of the Urbantech Hub @ New Lab, creating an additional layer of support for NYC start-ups through demonstration opportunities<br><br>-Explore how data can be leveraged to improve city processes<br><br>-Opportunity to fund cutting edge technology/research | -Indirect, rather than direct, job creation | -Supports the validation and commercialization of start-ups<br><br>-Enhances the efficiency of city operations and moves NYC towards a “smarter” city future |
| **DBP** | -Help tech companies pilot in "living lab"<br><br>-Collaborate with tech companies in exchange for data on quality of life to help improve services | -Getting data that is not easily managed by the BID in the long term<br><br>-Privacy concerns (real and assumed)<br><br>-The inability to use data gathered through the program due to barriers in City government | -Data helps DBP to make decisions about how to allocate resources, provide information for stakeholders, make updates to the public realm, plan better events that align with the desires of the community, identifies gaps in service delivery, and helps DBP to advocate for changes at the city policy level |

**Table 1:** The Circular City Program: Incentives and Risks *(continued)*

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **Numina** | -Opportunity to learn and work with other companies in a safe space<br><br>-Researchers documenting the process<br><br>-Opportunity to deploy technology in Downtown Brooklyn<br><br>-Marketable case study | -Uncertainty surrounding Circular City model at start of project | -To be able to test how Numina data can pair with other organizations' tools. |
| **CARMERA** | -Find use cases for CARMERA data | -Distraction from core commercial priorities | -Every advanced, large-scale transportation technology—from shipping to railroads to aviation—has converged upon an equilibrium for sharing critical data. It will be no different for AVs. When it comes to sharing information that is both critical for safety verification and useful for everyday planning and analysis, data that goes into AV maps (such as 3-D spatial models and pedestrian-density statistics) are perfect ways to deliver on this core transparency tenet without commercial risk. CARMERA is playing its part in this by making its data accessible to governing agencies of all types. |

**Table 1:** The Circular City Program: Incentives and Risks *(continued)*

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **Citiesense** | -Develop partnerships<br><br>-Deploy technology<br><br>-Low risk | -Small team with limited bandwidth<br><br>-Distraction from core commercial priorities | -In order to improve cities, we need a way to measure how people interact with cities and how cities respond to certain events. There's no single source of data that can effectively provide the insight needed for these measurements. Nor is there a single organization that controls the data for these measurements. Improving cities depends fundamentally on the many stakeholders and organizations that benefit from cities working together, adopting models that enable them to share data, and collaborating around better access to accurate information about different locations. |
| **ARCx** | -Design and lead never-before-done program for NYC<br><br>-Apply concepts developed in the *Smarter New York City* book<br><br>-Use data to create value for New Yorkers and apply research to the innovation of urban systems<br><br>-Be a part of a new and unique model of collaboration between the private sector, public sector, and academia<br><br>-Learn from some of the most brilliant minds in the urban tech and urban innovation field<br><br>-Mobilize new opportunities for students | -Create and define new concepts for urban challenges<br><br>-Limited amount of time to design, implement, and produce results<br><br>-Bring world-renowned scholars under a unified program vision and research agenda<br><br>-Limited time to create a sustainable funding model | -Create a data market not based on monetary transactions but on sharing and reciprocity<br><br>-Transparency<br><br>-Inclusiveness<br><br>-Homegrown economic development<br><br>-Acceleration of urban innovation<br><br>-Make cities smarter |

**Table 1:** The Circular City Program: Incentives and Risks *(continued)*

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **Cornell Tech** | -Opportunity to be a part of a new and unique model of collaboration between the private sector, public sector, and academia<br><br>-Opportunity to collaborate/form partnerships with the public sector, private sector, and academia<br><br>-New research published | -Time commitment | |
| **Columbia University's Earth Institute** | -Opportunity to be a part of a new and unique model of collaboration between the private sector, public sector, and academia<br><br>-Opportunity to collaborate/form partnerships with the public sector, private sector, and academia<br><br>-New research published | -Little to none | -Likelihood of finding new opportunities for improved policy-making<br><br>-Ability to test whether assumptions hold true—always better to have data to evaluate the effectiveness of policies and their operations |
| **NYU's GovLab** | -Program aligned well with GovLab's mission<br><br>-Interesting project<br><br>-Further GovLab's research agenda | -Little to none | -Cross-sector data collaboration |

**Table 1:** The Circular City Program: Incentives and Risks *(continued)*

| | **Incentives** | **Risks** | **Value of Circular Data** |
|---|---|---|---|
| **Citi Ventures** | -Strategic partnership with New Lab<br><br>-Opportunity to be a part of a new and unique model of collaboration between the private sector, public sector, and academia<br><br>-Opportunity to collaborate/form partnerships with the public sector, private sector, and academia<br><br>-Opportunity to fund cutting edge technology/research | -Financial risk of joining the program<br><br>-Initial investment | -Enables creating more powerful products and offerings for clients |

## III. Program Kickoff

On May 23, 2018, David Belt, Founder and CEO of New Lab, publicly launched The Circular City program with the help of key stakeholders, including Numina, CARMERA, and Citiesense, DBP, EDC, and representatives from Columbia University and Cornell Tech. Following Belt, Brooklyn Borough President, Eric L. Adams, took the stage with an inspiring call to action and support for The Circular City, stating that, “What we do in Brooklyn will be the direction that New York City travels, and the direction that New York City travels is the way the world travels.”

Start-up founders Tara Pham, Ro Gupta, and Starling Childs also took the stage, each taking time to showcase the cutting-edge technology The Circular City would allow them to pilot. A panel ensued, led by Shaina Horowitz and featuring key partners of The Circular City, including Regina Myer, President of the Downtown Brooklyn Partnership, Francesca Birks, Associate Principal of Foresight & Design Strategy at Arup, Sander Dolder, and André Corrêa d’Almeida (Horowitz 2018a).

The launch was followed by a convening in early June 2018, during which research teams from Columbia University, Cornell Tech, and NYU’s GovLab met with André Corrêa d’Almeida and Shaina Horowitz at

New Lab to discuss the idea of circular data as the first exploration of New Lab's The Circular City program. On the research teams' minds were the pressing questions: "Just how valuable is data, specifically the data that Numina, CARMERA, and Citiesense produce for the topic I am studying?"; "Value for whom?"; "Value in reference to what?"; "How can we put a value on circular data?"; "How will data be circulated?" From this meeting it was decided that the research teams would meet separately with the start-ups to discuss these questions from the standpoint of each start-up and each specific issue the research teams were in charge of: resiliency, mobility, and economic growth.

Each meeting between start-up and research team brought something different to the table. Within the meetings, conversations around resiliency, mobility, and economic growth took place between the start-ups and the research teams. Researchers came prepared with questions for the start-ups like: What raw data do you collect? How frequently do you collect it? What data do you produce, both internally and externally? What third-party data do you use, if any? What is your business model? How do you scale-up? The meetings also gave the start-ups a chance to explain their technologies to the research teams.

Meetings were most productive when the stakeholders were able to attend in person, although it was not always possible. This highlights one of the early challenges the program faced. The Circular City's strength lay partially in its high-profile, expert participants, but working with so many in-demand individuals and organizations made scheduling difficult. Factors like phone meetings and paternity leave were a reality for The Circular City program (three babies were born to Circular City participants over the course of this case study!), and it was of the utmost importance that the collaboration remained flexible and accommodated stakeholders when necessary.

As researchers began working on their papers, CARMERA was enjoying huge success. In August 2018 CARMERA announced both an expansion to Japan and South Korea and that they had raised $20 million, which they would use to continue to improve how they address challenges related to growing urban populations. This exemplified The Circular City's ability to create opportunities for urban tech companies to collaborate with cities. Throughout a time of immense and exciting growth for CARMERA, The Circular City provided a low-risk option at the neighborhood level to test a market opportunity that could become a significant component to how CARMERA scales its business in the future (Horowitz 2018d).

Meanwhile, Numina was gearing up for a highly-anticipated deployment of their sensors. Numina's sensors were scheduled to be mounted onto DBP-owned light poles at the intersection of Fulton and Flatbush, a highly-trafficked junction in Brooklyn identified by DBP, New Lab, and Numina as an area of high interest. The intersection represents where Fulton Mall, a local shopping corridor and area that has been intentionally transformed into a pedestrian and bus zone (closed to regular traffic), intersects with Flatbush Avenue, one of the busiest throughways of Brooklyn and an artery that experiences consistent and often pronounced congestion. In fact, the intersection is so representative of the pace of life in Brooklyn that New Lab's Shaina Horowitz referred to the intersection as "the heart of change as it's happening." The juncture was chosen for logistical reasons as well: at this location sensors could be installed on infrastructure (light poles) controlled by DBP, which cut out the permissions and bureaucratic roadblocks to deploying new technologies in public space that are often triggered by such tests. At this

site, New Lab could rely on DBP's support as a partner to expedite the installation process, rather than contracting multiple building owners and city departments such as DOT.

One unexpected, albeit small, roadblock the program faced was that the timeline for deployment of the sensors, originally scheduled for July 2018, kept getting pushed back. This was partially due to a delay at the manufacturing facility Numina was using to manufacture its latest product (the Metropolitan Transit Authority [MTA] had placed a large order with the manufacturer around the same time), but also because certain aspects of the agreement and planning with DBP required further sign-off and negotiation, more than originally anticipated. Additionally, New Lab was negotiating a contract that would allow DBP, after the initial six-month pilot, to do further business with Numina without the hassle of going through the usual procurement channels, if they chose to do so. In essence, this made The Circular City program a low-risk, no-cost opportunity for DBP to familiarize themselves with Numina's product and team before considering officially entering into a partnership. In concert with this, New Lab and DBP collaborated to create a process that outlined how a start-up, put forth by New Lab, could work with DBP in an effort to promote, streamline, and even expedite collaborations in the future. While putting these agreements into place for the first time required lots of back and forth, ultimately the hope is that it will expedite the process in the future.

Numina's sensors were deployed in September of 2018, marking an exciting moment for The Circular City. For the next six months Numina's sensors would be collecting real-time data. Tara Pham, Numina Co-founder and CEO, stated that, "We are excited to work in our own backyard with Downtown Brooklyn Partnership and New Lab in this rare and important opportunity for us all to think more experimentally about our shared spaces. This collaboration is about demonstrating the value of more data-driven, multidisciplinary approaches to managing the public right-of-way—so cities can be more proactive, rather than reactive, about planning toward people-first values" (Horowitz 2018c)..

## IV. Maintaining a Collaborative Model

By October 2018, The Circular City collaboration was in full swing. Numina sensors were deployed in the living lab of Downtown Brooklyn, Citi Ventures had signed on as a corporate partner, and the research teams had begun developing their papers on resiliency, mobility, and economic growth. Relationships were beginning to form between participants. New Lab's vision of a virtuous cycle of collaboration, complete with the opportunity to experiment and the ability to receive real-time feedback, was coming to fruition.

One important process the research teams were engaging in was connecting with New York City agencies. For example, the mobility research team, led by Cornell Tech's Arnaud Sahuguet, had formed a relationship with NYC's DOT in an effort to understand how the agency uses data. Sahuguet's findings show that the DOT uses mobility data for four distinct purposes: planning, impact measurement, prioritization, and enforcement (more on this in Sahuguet's entry in this journal).

Meanwhile, members of The Circular City team were busy preparing for the MacArthur Foundation's Opening Governance Research Network, a two-day conference held at New Lab and chaired by NYU's

GovLab. The convening focused on the reimagining of public-private partnerships and marked a unique opportunity to share the work of The Circular City program. Attendees included interdisciplinary experts and scholars from distinguished institutions like the Laboratory for Innovation Science at Harvard (LISH), the Pew Research Center, Arizona State University's School for the Future of Innovation in Society, Nesta, UNICEF, the New York City Mayor's Office of Data Analytics, and more. Also in attendance was The Circular City start-up cohort: Numina, CARMERA, and Citiesense, who contributed to the discussion of the future of public-private partnerships. Panelists included The Circular City's own Shaina Horowitz, Stefaan Verhulst, and André Corrêa d'Almeida. In a November 5th press release on the event, Horowitz stated that, "while the specific mandate of public and private players in the new tech-enabled city continues to evolve, what is no longer up for debate is that both need to play a role. More than ever, what's needed is a framework that empowers city governments, enterprises, start-ups, and civil society to develop a sustainable, scalable model of circular data, where all can benefit from the value created."

Around the same time, Corrêa d'Almeida was gearing up for the 2018 Circular Economy European Summit (CEES) on Cities, a global conference held in Barcelona, Spain. Corrêa d'Almeida was asked to present at the conference on The Circular City program, representing New York City's circular strategy and international attention for the fledgling program. Alongside Corrêa d'Almeida sat fellow presenters from the World Economic Forum, the City of Barcelona, the German Sustainable Building Council, the Organization for Economic Cooperation and Development (OECD), UNESCO, and more.

In early December the full Circular City team came together for a series of participatory roundtables to review the first versions of each research paper. The participatory roundtables, a methodology Corrêa d'Almeida developed for his book, *Smarter New York City: How City Agencies Innovate,* and expanded in The Circular City program, were a great success. New Lab hosted four sessions in total in December 2018, one on the production of this case study, and three on the development of the research papers regarding mobility, resilience, and economic development. For many participants, this was their initial meeting with Citi Ventures and the first time they were seeing the results of the research papers. The stakeholders, many of whom hadn't convened since September, provided highly-valued feedback to the research teams. Following the roundtables, the papers were circulated amongst the stakeholders for further revision.

The roundtables, while highly valuable, were symbolic of the program itself: a model of collaboration in which voices from several sectors were not only heard, but used to build ideas on one another. It was what the entire program had been building up to. The effort to create a massive cross-sectoral collaboration had finally been realized. Corrêa d'Almeida, taken aback by the level of engagement and overall success of the initial roundtable, wrapped up the meeting by saying that perhaps "'grand experiment' better captures what we are trying to do here than 'pilot.'"

## V. The Value of Circular Data: What is it Worth and Why Does it Matter?

Circular data is at the forefront of The Circular City program, although it isn't the only aspect of the model itself. The model overall contains ingredients of dialogue, trust-building, collaboration, piloting, experimenting, hypotheses-testing, partnering, and coordinated action to tackle quality of life issues. Circular data, however, was chosen as a medium, conduit, and flow for the collaboration.

While the EDC initially wanted the program to tackle issues related to moving NYC towards a zero-waste circular economy, it was mutually decided that this topic was both too vast and too abstract to tackle in the first year of the program. There was no problem set that could be articulated or technology that could be tested that would meaningfully make progress towards a circular economy. The idea of "circular," however, had staying power; it became an apt metaphor for the set of relationships the program sought to create (collaborations that, if cultivated in the right way, could eventually help the transition towards a circular economy). Namely, New Lab identified the prime function that each stakeholder group represented and sought to create a virtuous cycle of collaboration whereby technology could be rapidly developed, tested, evaluated, and scaled.

But why data as the first exploration in this grand experiment? New Lab understood that as IoT and AI are introduced into the arena of a city, the realities of data use are complicated and amplified in entirely new ways. Many are heralding the dawn of a new data-driven paradigm for urban development and city innovation, but few have truly experimented with the implications, the shortcomings, and the challenges that these new technologies represent. Further, though we talk of an overabundance of data, it's often still not visible or tactically wielded at the local level in a way that benefits people. New Lab knew that immense amounts of data were being collected and that pulling data together in a meaningful way could be very powerful. Additionally, data holds new revenue-generation opportunities, serves as a new set of tools for policy makers and public officials, and represents a revenue stream that many new tech and legacy businesses are exploring, especially as the proliferations of the smart-cities market continues (a market of high importance to many of New Lab's members).

Circular data as a medium for collaboration provided an incentive for entities to join The Circular City program, not only as an outlet to collect new data sets, but also to share business insights and gain access to new business opportunities, as illustrated by the business dialogues between Citiesense and CARMERA that was initiated through The Circular City program.

The research teams knew that data was highly valuable to their topic of study, but, they wondered, just how valuable is circular data? And why would "circular data" matter when mainstream business models rely on price mechanisms to incentivize demand and supply exchanges? Naturally, these questions proved difficult to answer. In short, the answer is: it depends! Circular data is valued differently based on various factors, which led to some of the following questions: Can the data (that you want to put a value on sharing and reusing) be found from a different source, or does it not exist yet? Are there analytical tools available to understand the data? Is the data actionable? What is the demand for the data? Is there a market need for it? Does a data gap exist? What would the data be used for? Who would it be used by?

It's important to note that even with answers to these queries, the promise of circular data is only as real as the analytical tools available to understand it and use it to make decisions in a different way. For example, without a front-end analytical data tool, the intelligence collected and shared to a New York City agency wouldn't be of much use without a data scientist. A front-end tool would make the data actionable, meaning that a layperson would be able to draw insights and conclusions from the data. However, even with data *and* a front-end tool to analyze it with, the question remained: what is the demand for this data?

One of the early challenges research teams faced was that there was little to no knowledge about existing data gaps, making it nearly impossible to measure the demand for data. Further, even if the demand for data was known, the value of it would likely change based on *who* wanted the data, which led the research teams to continue circling back to the same question: value of data for *whom*?

One way of testing the "circular data value" hypothesis is to look at the structure of the demand and supply of data and try to simulate a data sharing market; i.e., make demand and supply meet, without price and monetization mechanisms.

In order to understand both the demand and the supply sides of a potential circular data market, research teams asked start-ups and selected city agencies four foundational questions:

1. What is your business proposition and values?
2. What types of data do you produce or collect?
3. What additional data sets would you like to have access to?
4. What data are you willing to share?

In addition, research teams asked industry experts the following question about start-ups and city agencies:

5. What additional data sets should these start-ups and city agencies have access to?

Research teams also explored different circular-data markets: G2B (government to business), B2B (business to business), and B2G (business to government). The three papers that follow discuss and measure in detail the value of circular data within the context of the three critical urban challenges studied while focusing on these three different aspects of circularity.

## VI. Conclusion: Measures of Success, Replicability, and the Future of The Circular City

While the title of this section reads "Conclusion," this case study only tells the story of the first 10 months of The Circular City program. What started as an idea has been transformed into a program of immense value for its participants. These participants, at the onset, trusted in the leadership and took a leap of faith in joining such a novel initiative. This section will explore the successes of the program, as well as guidelines for replicating it, and what the road ahead looks like for New Lab's The Circular City program.

## A. Measures of Success

Monitoring and measuring success is crucial for The Circular City program. Throughout the program, series of interviews were held with stakeholders to understand what the idea of "success" meant for their individual participation in The Circular City program, both during the 10-month grand experiment and beyond (see Table 2).

**Table 2:** The Circular City Program: Measures of Success by Stakeholder

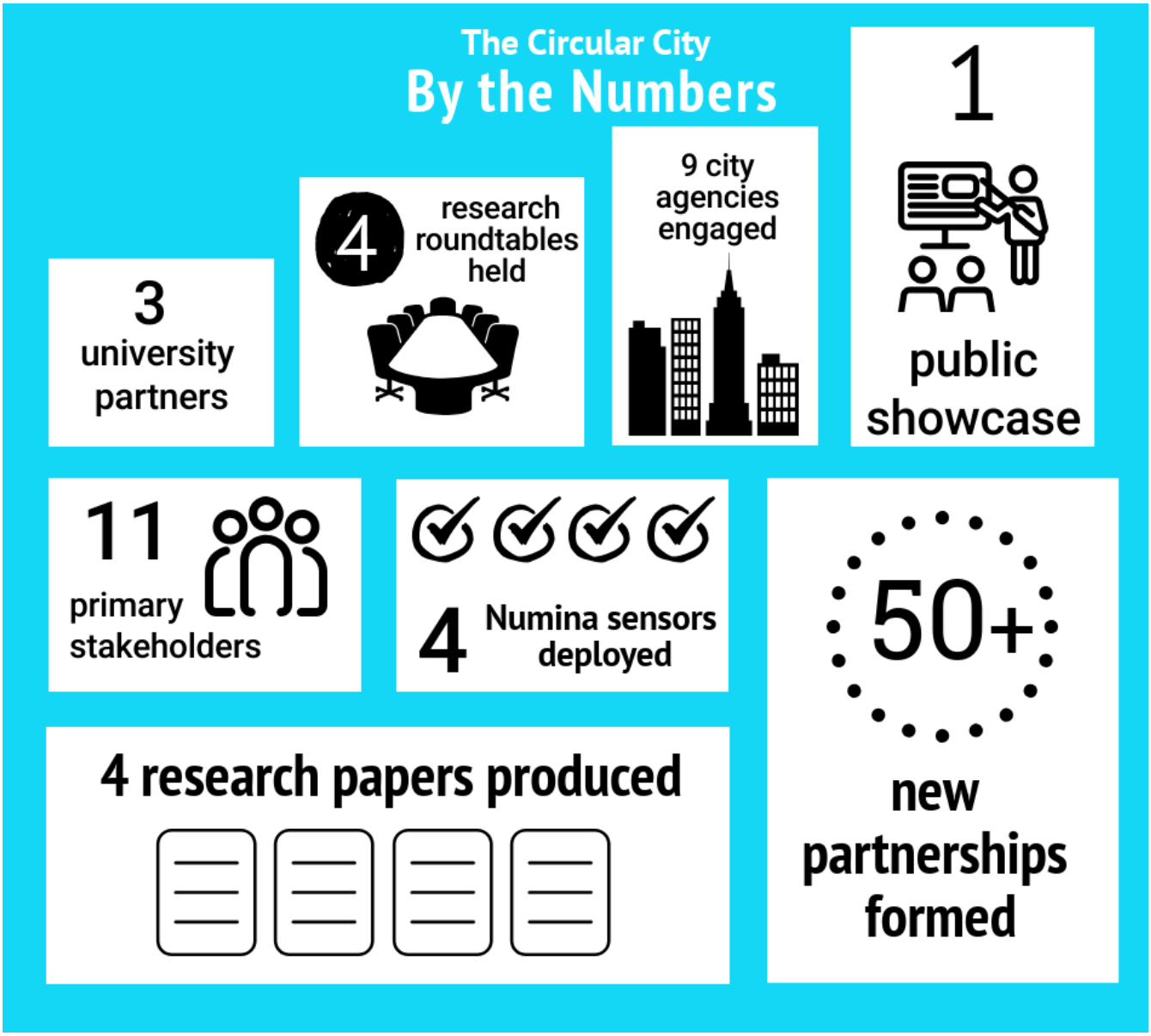
| | **Year 1: The Grand Experiment** | **Future: The Scale-up** |
|---|---|---|
| **New Lab** | -Attract a diverse set of stakeholders to participate in the program<br><br>-Facilitate new collaborations between stakeholders of the program<br><br>-Deploy real urban tech products in New York City<br><br>-Help start-up(s) apply learnings from research to inform product development and new partnership opportunities<br><br>-Help start-ups and engaged stakeholders validate hypotheses/use cases<br><br>-Help start-ups, researchers, city, and corporate partners uncover new use cases<br>Produce new research that takes as its central theme a series of pressing urban challenges and the assets start-ups bring to bear on these challenges | -Number of pilots that turn into future business development for those engaged<br>Number of investments, partnerships, or acquisitions made<br><br>-Ability to attract both public and private funding on a multi-year basis to replicate and scale program<br><br>-Ability to use mechanisms of collaboration to develop MVPs and new products that deliver value to all collaborators<br><br>-Ability to identify and prioritize problem sets and recruit relevant start-ups and collaborators<br><br>-Ability to bring the program model to cities beyond New York<br><br>-The scale/status of start-ups who have participated in year 1 and year 5<br><br>-Ability to create a "playbook" that meets the demands of the challenge at hand while being responsive to local needs and conditions |
| **EDC** | -Number of relationships formed and connections made<br><br>-A collection of best practices and lessons learned for the next round of the program | -Indirect jobs created<br><br>-Development of replicable model for the secure sharing of data<br><br>-Engage more city agencies<br><br>-Explore how procurement would factor into sharing data with city entities |

**Table 2:** The Circular City Program: Measures of Success by Stakeholder *(continued)*

| | **Year 1: The Grand Experiment** | **Future: The Scale-up** |
|---|---|---|
| **DBP** | -Cost savings for the BID from efficiencies found through data | -Data used by BIDs to advocate for changes to the public realm |
| **Numina** | -Ability to pilot technology<br>Gain insights from research papers | -Receive user feedback |
| **CARMERA** | -Number of BIDs using CARMERA data exhaust<br><br>-Reporting feedback about usage | -Number of BIDs participating in data sharing with CARMERA |
| **Citiesense** | -Proof that the Citiesese platform for neighborhood data can integrate with a range of important third-party data sources, such as CARMERA and Numina<br><br>-Proof that data, once centralized, can be used to facilitate pragmatic use cases for stakeholders at the local level by clearly presenting the relationships between many location data sources on the same map | -Number of neighborhoods to adopt technology like CARMERA's mobility data and Numina's sensors |
| **ARCx** | -Four high-quality papers published<br><br>-Four participatory and content-rich roundtables<br><br>-Collective decision to expand the program into 2019<br><br>-Requests from other scholars and universities to join the program<br><br>-Collaboration and collective learning among participating stakeholders<br><br>-One very successful public showcase of the Circular City Program | -Expansion of the research agenda<br><br>-Readership and applicability of research produced and published<br><br>-Participation of more universities<br><br>-Development of data sharing/circular-data tech platform<br><br>-Expansion of start-ups' businesses<br><br>-"Smarter" city agencies<br><br>-Expansion of The Circular City Data Program to other cities in the U.S. and around the world |

Below, Figure 5 summarizes the results and some of the successes of the 10-month grand experiment.

**Figure 5:** The Circular City Program: Summary of Results




## B. Replicability and Conditions for Success

One of the ideas that came out of the roundtables was the notion of "conditions for success," and, in particular, what were the conditions that allowed The Circular City experiment to be so successful? Further, what conditions may have allowed the pilot to be *more* successful? If this model is to be replicated or expanded, we've deemed the following conditions vital to success.

*Choosing the Right Partners*

When building a new model of collaboration, choosing the right partners is of utmost importance. Additionally, it's powerful to not only access and engage public leaders, universities, and start-ups, but also to bring investors and enterprise-level partners to the table to help scale promising concepts. Together, the “right” partners should bring a mixture of significant resources to the table, in the form of funding, access to infrastructure, subject matter or technical expertise, exposure and/or visibility, and access to proprietary resources, such as data or customers.

*Engagement of City Agencies*

It is important to engage with city agencies early on in the process. For example, identifying the demand for data within city agencies, and having city agencies at the table throughout the process, is a key element for success. Additionally, any problem or topic area should have a clear “client” who is engaged throughout the process providing feedback and driving towards outcomes they’ll be able to implement, learn from, and invest in.

*Maintaining Partnerships and Focus on Value Added for All*

Long lasting, true, collaborative partnerships require maintenance. Designing a stakeholder analysis and/or an incentives framework early on will help leadership ensure that partners are obtaining the utmost value from each pilot, and in turn will result in leadership obtaining the utmost value from the pilot. Additionally, roundtables are recommended in order to receive stakeholder feedback. Depending on the length of the pilot, multiple roundtables may be ideal.

*A Vision and Committed Leadership*

Leadership is vital for a collaboration of this nature and size. Managing expectations, ensuring needs are met, mobilizing the right type of highly-motivated talent, and developing proper communication and feedback channels is crucial to forming meaningful partnerships. It is essential that leadership understands this and is committed to the success of the model, both during the pilot stage and looking into the future. Leadership must create a shared sense of purpose where opportunities and risks for the common good are properly assessed, explored, or mitigated.

## C. The Future of The Circular City: The Road Ahead

Started as a New-Lab-led initiative, The Circular City now has a life of its own: molding and shaping itself while creating circular ripple effects across the world. While the exact future of the program remains unknown, the current stakeholders agree: it needs to scale-up.

From the onset, The Circular City’s goal was to scale-up in 2019 and beyond. This desire has only grown stronger over the course of the program as research hypotheses around the value of circular data were

being confirmed. Stakeholders continue to be committed to designing for scale and for maximum impact to solve the most pressing challenges facing us today. Not only is scaling-up on stakeholders' minds, but participants are eager to expand the program too, with an aim of bringing The Circular City to the world's largest metropolises.

Today, the eleven primary stakeholders of The Circular City program enjoy collaborative partnerships with one another, which continue to transform into something unprecedented. The Circular City can be deemed not only a successful grand experiment, but an entirely new model of collaboration altogether.

## References

Corrêa d'Almeida, André ed. 2018. *Smarter New York City: How City Agencies Innovate*. New York: Columbia University Press. https://cup.columbia.edu/book/smarter-new-york-city/9780231183758.

Downtown Brooklyn Partnership. n.d. "About Us." Accessed February 6, 2019. http://downtownbrooklyn.com/about.

———. 2019. "Why Downtown Brooklyn: Quick Facts." Published January 2019. http://s3.amazonaws.com/downtown-brooklyn/imgr/Why-Downtown-Brooklyn_Quick-Facts.pdf.

Horowitz, Shaina. 2018a. "The Circular City: A New Model for Collaboration." May 30, 2018. https://newlab.com/stories/circular-city-model/.

———. 2018b. "How Data Creates Value in Cities." November 5, 2018. https://newlab.com/stories/how-data-creates-value-in-cities/.

———. 2018c. "Numina Brings IoT and Real-Time Insights to NYC." September 20, 2018. https://newlab.com/stories/numina-circular-city/.

———. 2018d. "What CARMERA Can Teach us About Private-Public Collaboration." September 19, 2018. https://newlab.com/stories/carmera-circular-city/.

Newcomer, Eric. 2018. "Uber Agrees to Buy Electric Bicycle Rental Company Jump Bikes." *Bloomberg*, April 9, 2018. https://www.bloomberg.com/news/articles/2018-04-09/uber-agrees-to-buy-electric-bicycle-rental-company-jump-bikes.

# Circular Data for a Circular City: Value Propositions for Economic Development

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## Summary[1]

In this paper, we examine the value of circular data for economic development in the City of New York and Downtown Brooklyn in particular. Focusing on data that could be made accessible by three start-ups participating in the Circular City program—CARMERA, Numina, and Citiesense–this paper has three central components. First, it develops a framework for thinking about the potential and realized value of circular data, sorting potential uses into five categories: Situational Analysis; Cause and Effect Analysis; Prediction; Impact and Value Assessment; and Ecosystem Support. Second, it identifies and analyzes a number of circular data-driven use cases across these categories. Finally, we reflect on the enabling conditions, challenges, and risks associated with the use of circular data, and provide several recommendations for practitioners to maximize impact of circular data on economic development objectives.


## Introduction: Economic Development Imperative

The City of New York is the result of and depends on a vibrant economy.

As with other cities, the City's lifeblood is its employment base and economic activity. Without a vibrant economy and jobs that provide economic security, current residents will leave and future residents will be discouraged from moving to the city. The public services provided by the city are only feasible by taxing the economic activities of its citizens and businesses, who in turn benefit from those services being delivered. Yet challenges remain.


[1] Acknowledgements:

The authors of this paper would like to thank our fellow researchers on The Circular City Program, including Caroline McHeffey, Nilda Mesa, and Arnaud Sahuguet, as well as collaborators at New Lab, especially Shaina Horowitz and Cait Shubick, and representatives from the start-ups under consideration in this paper: CARMERA, Numina, and Citiesense. Our work also greatly benefited from participants at a roundtable discussion, including: Shaina Horowitz, New Lab; Cait Shubick, New Lab; Laura McGarrity, New Lab; Shaun Stewart, New Lab; André Corrêa d'Almeida, Columbia University; Caroline McHeffey, Columbia University; Zachary Ho, Citi Ventures; Romina Cunza, Citi Ventures; Arnaud Sahuguet, Cornell Tech; Nilda Mesa, Columbia University; Sander Dolder, New York City Economic Development Corporation (EDC); Mae Stover, EDC; Jonathan Lane, EDC; Charlotte Laffler, Downtown Brooklyn Partnership (DBP); Jessie Lazarus, CARMERA; Tara Pham, Numina; Paul de Konkoly Thege, Numina; Star Childs, Citiesense; Carl Cornilsen, Citiesense; Dana Chermesh, DRAW Brooklyn. We also obtained invaluable input during a convening of the MacArthur Foundation Research Network on Opening Governance, hosted at New Lab, attended by: Aleks Berditchevskaia, Neil Britto, Jasmina Byrne, Nina Cohodes, John Harlow, Andrew Hoppin, Sheena Iyengar, Erik Johnston, Justin Kreamer, Beth Simone Noveck, Lee Rainie, and Adrienne Schmoeker.

Finally, we gained expert input from practitioners across the public and private sectors, helping to guide our research and considerations of the potential value of circular data for addressing economic development needs in Downtown Brooklyn. Thank you to Lauren Andersen, Michael Blaise Backer, Rob Holbrook, Archana Jayara, Nisha Mistry, Carlos A. Ortiz, Rachel Van Tosch, and Ken Zita.

An increasingly challenging issue involves preventing radical disparities in distribution of wealth and services across the city. Gentrification has often displaced low-income families to other poorer areas, accelerating inequality.

Finding ways to increase economic activity, generate new jobs, and prevent economic inequality is thus essential for any actor within city government and for the well-being of any NYC resident or visitor.

This paper explores whether and how "circular data"—the collection, production, and exchange of data, and business insights, between a series of urban collaborators around a shared set of inquiries—can help economic development by empowering both government actors (i.e., through B2G models), as well as the local business community (B2B) (Corrêa d'Almeida and McHeffey 2019). It looks specifically at circular data generated by three companies participating in New Lab's Circular City program: CARMERA, Numina, and Citiesense.

We examine how data about New York City (and specifically Downtown Brooklyn) from these start-ups can help the city achieve its economic development priorities while providing businesses new opportunities to increase revenue and market share, optimize existing processes, or launch new products and services.

## Priorities for Economic Development

New York is thriving, based on some metrics. Unemployment is low (New York State Department of Labor 2019). Job creation is up (Glen et al. 2017). Major technology companies see the City as an attractive location to base their operations (Day One Staff 2018). Still, serious difficulties remain. Old industries are in transition (Crudele 2017). Neighborhoods are changing. Long-established businesses and residents find it increasingly difficult to stay afloat amid an influx of new arrivals and increased property prices (Small 2017). As articulated in Mayor Bill de Blasio's *New York Works* report:

> "Hundreds of thousands of working New Yorkers struggle to earn enough to afford raising a family [and] the jobs and sectors that historically supported our middle-class are in tremendous upheaval. These challenges cut to the heart of the city we want to be." (Glen et al. 2017, 3)

To assess the value of circular data for economic development we sought first to assess the economic development problems and priority areas as identified by stakeholders across the New York City government, especially those affecting Downtown Brooklyn. We interviewed representatives from the New York City Economic Development Corporation (EDC) as well as from New York City government agencies like the Department of Small Business Services, Department of Consumer Affairs, and Department of Buildings. Lastly, we engaged with the three companies participating in New Lab's The Circular City program—CARMERA, Numina, and Citiesense—industry consultants, and business professors to gain a deeper understanding of the potential B2B value of circular data. This business value of circular data is considered in the context of public problems and opportunities.

Based on insights from these stakeholders and additional research and analysis, we identified the following top priorities for New York City from an economic development perspective:

- **Improving and Maintaining Infrastructure:** While noteworthy improvements have been made to New York's infrastructure over the last few years, significant needs still have to be met. The Center for an Urban Future estimates the city's physical infrastructure needs at least $47.3 billion to repair and maintain existing infrastructure, with the cost of unmet repairs likely to reach $34.2 billion over the next five years (Forman 2014). This estimate does not include the new developments or expansions that will likely be needed as the city continues to gain in population.

- **Promoting Environmental Safety:** The City of New York, including Downtown Brooklyn, faces serious problems due to air and water contamination. Each year, excessive air pollution causes more than 3,000 deaths, 2,000 hospital admissions for lung and heart conditions, and 6,000 emergency room visits (Kheirbek et al. 2011). Further complicating these problems are the effects of climate change and New York City's growing vulnerability to sea-level rise and extreme weather events. By 2050, mean annual temperature in the city will likely increase between 4.1 and 6.6°F, leading to "extreme weather [that] will increase in frequency and severity" (New York Mayor's Office of Recovery and Resiliency 2018, 5).

- **Fostering Community Wellness:** A healthy and resilient community requires more than just the physical health of its residents; it depends also on its cohesion and the willingness of neighbors to help one another in times of need. It is about how interdependent variables—business districts, education systems, traffic systems, and health provision systems—interact with and support one another. With the influx of new residents to many neighborhoods across Brooklyn and the pricing out of low-income residents, many people are concerned about a growing strain on those ties. In neighborhoods like Williamsburg, for example, the Hispanic population plummeted 16 percent between 2000 and 2015 (Campanile 2017).

- **Increasing Access to Affordable Housing:** The city's increasing desirability and economic prosperity has caused a shortage of affordable, low-income housing. According to the Office of the New York City Comptroller, between 2005 and 2017, "rising rents led to the disappearance of over 425,000 apartments renting for $900 or less (in 2017 dollars) from the city's inventory" (Office of the New York City Comptroller 2018). The supply of housing has failed to keep up with the city's growth. Consequently, many residents have been displaced from their neighborhoods. In 2017, Brooklyn lost 2,000 residents, the borough's first net population loss since 2010 (Bliss 2018).

- **Stimulating Wage Growth and Employment Creation:** New York City's prosperity depends upon the availability of well-paying jobs. Without well-paying jobs, the city attracts fewer residents and can afford fewer public services. In Brooklyn, spurring sustainable job growth has been a particular priority. Since 2009, Brooklyn has added 172,600 private-sector jobs and has outpaced growth in the other five boroughs (Office of the New York State Comptroller 2018).

In what follows, we seek to assess how circular data can contribute to these priorities, directly or indirectly. For instance, we look at ways in which circular data can increase business revenue, optimize existing processes, or provide opportunities for innovation. We also look at the conditions that can allow businesses to achieve these goals, as well as risks and barriers to success.

### The Imperative and Priorities for Business

Today, it is widely held that data has the power to fuel economic growth, job creation, and new business opportunities. This fact holds true across regions and sectors. In the European Union, for instance, the direct market value of open data between 2016 and 2020 is estimated to reach EUR 325 billion ($367 billion) (Berends, Carrara, and Radu 2017). In the United States, public officials share data because they believe open data can unlock $3 to $5 trillion in economic value annually across seven sectors (The World Bank 2019). New York has become an international leader in technology and innovation, due in part to public and private leaders embracing and leveraging data. In 2018, city leaders published 629 new data sets to the NYC Open Data platform, bringing the total amount of data sets to over 2,000 (New York City Information Technology and Telecommunications 2018).

Business models leveraging data drawn from and representing key aspects of city life are increasingly gaining traction. But for all the excitement about the potential business value of such data, as well as the dominant narratives around the so-called “smart city” movement, relatively little is known about the precise variables, parameters, and pathways through which circular data translates into growth and opportunities.

### Priorities for Businesses Seeking to Create Value from Circular Data

Interviews with data-generating businesses and other stakeholders, as well as a review of the literature, brought into focus three key priorities for businesses seeking to create value from circular data:

1. **Increasing revenue and market share**: The most direct business value that can be generated through circular data, comprising both revenue generated through new clients and paid service delivery opportunities, as well as increased demand for the business’s product or service.
2. **Optimizing existing processes**: The generation and analysis of circular data can enable businesses to optimize or gain new insights into their business practices, and to increase productivity as a result.
3. **Innovation:** As evidenced by the diversity of circular data use cases described below, the potential utility of circular data sets is vast and varied. As businesses generating such data continue to evolve and collaborate with additional partners, new and unexpected use cases are likely to arise, potentially leading to entirely new business models and opportunities.

## The Potential and Realized Value of Circular Data

Cities around the world are seeking new ways to leverage data to improve service delivery and bolster economic development. Based on our research into the broad field of private-sector data being used in the public interest,[2] we approach the value of circular data for economic development along five vectors:

1. **Situational Analysis**: Through the increased ability to access and analyze previously inaccessible information, circular data can enable stakeholders across sectors to better understand, often in real-time, trends in city activity and the geographic distribution of various phenomena (e.g., population flows and new business activity).
2. **Cause-and-Effect Analysis**: Circular data can be brought together with widely dispersed data sets, in the process creating a better understanding of possible correlations and causalities, as well as what variables make a difference for what type of problem.
3. **Prediction**: Richer, more-complete information from circular data can enable new predictive capabilities for policy makers and others, allowing them to be more proactive and to assess future risks, needs, and opportunities.
4. **Impact and value assessment**: Through improved monitoring and evaluation, public-interest actors and other businesses can rapidly assess the results of their interventions to iterate on products and programs when necessary.
5. **Ecosystem Support**: Circular data can make visible previously obscured interdependencies and their impacts on issues relevant to the economic health of the city, such as social cohesion at the neighborhood level.

Just as different goals and operations led the companies to collect different types of data, so too did their different data collections make them suited to address different value vectors. While each company could, theoretically, provide value to each of the five vectors, our desk research, analysis, and interviews suggested the companies could provide the most value in a handful of areas:

| | CARMERA | Numina | Citiesense |
|---|---|---|---|
| **Situational Analysis** | ■ | | |
| **Cause and Effect** | ■ | | |
| **Prediction** | | ■ | |
| **Impact Assessment** | | ■ | |
| **Ecosystem Support** | | | ■ |

[2] These categories are adapted from the GovLab's previous work assessing the value of Data Collaboratives, initiatives where corporate data is leveraged to provide for more data-driven approaches to public problems, is becoming a key factor in developing innovative solutions. For more information, see Verhulst, Young, and Srinivasan (2018).

These findings inform the possible use cases, the key value propositions, identified below. This research recognizes that many of these cases are already being addressed, in some fashion, by existing public and private organizations. As such, it tries to indicate that fact where possible.

This paper's value, however, is in suggesting how circular data could contribute to further enhancing this work, transforming promising pilot programs and one-off academic exercises into systematic processes that capture the full potential of proposed solutions. It achieves this goal by arranging each of the use cases in a "Data Value Canvas" to help readers understand the different facets of the use cases. Though it focuses on data provided by just a few start-ups, the use cases demonstrate the nuances of their data sets and the analytics required to make them useful—as well as the potential value amplification resulting from additional data sets being brought to the table. Most importantly, it also provides a methodology that could be used to assess the value of the circular data ecosystem.

<table>
<tr><td rowspan="2">Problem and Context<br><br>Overview of how the problem under consideration manifests and what steps have been undertaken to address the problem.</td><td>Data sets Provided by Start-Ups<br><br>Listing of the five types of circular data sets that could provide value:<ul><li>Pedestrian Analytics</li><li>Street-Level Still Images</li><li>Fixed-Street Asset Locations</li><li>Vehicle Movements</li><li>Commercial Space Usage</li></ul></td><td>Beneficiaries<br><br><u>Public:</u> City government agencies and civil society actors that could benefit from circular data uses<br><br><u>Private:</u> Businesses that could benefit, through, for example, B2B models</td></tr>
<tr><td>Key Value Proposition:<br><br>The proposed value to be created through the use of circular data.</td><td>Social Value<br><br>The purported societal benefits of the use of circular data</td></tr>
<tr><td>Risks and Challenges<br><br>Operational barriers that could limit success and important risks (e.g., to personal privacy or data security) that could impact the use of circular data.</td><td>Monetary Value<br><br>Quantifiable signals of the cost savings and/or revenue generation that could result from the use of circular data.</td><td>Enabling Conditions<br><br>Operational factors that could help determine the success or failure of a circular data project.<br><br>Sources: Additional resources and supporting evidence.</td></tr>
</table>

### Situational Analysis

Analysis generated from a more accurate and up-to-date scan of the city is valuable for a variety of sectors and applications. Areas as diverse as real estate, energy, and environmental management could benefit from improved situational analysis capabilities. Such capabilities could also support traffic management to enable dynamic routing, reduce cost, and assess pollution, which in turn could lead to improved public health with its own impact on productivity.

More robust assessments of real-world conditions can also update historical perceptions or human bias of an area that prevents investment in specific neighborhoods or zones in a city (enabling data-driven investment propositions), which could lead to reduced inequality, new affordable housing, and increased small business activity.

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| The City of New York is a large and vibrant city, but many properties fail to meet the city's standards for health and safety. While the Department of Buildings, the city agency responsible for inspecting properties and ensuring compliance with regulations, is working hard to identify these problems, its resources are often limited. In one audit by the New York City Comptroller, department "[o]fficials cited insufficient resources as the primary reason for failing to meet their own goals"(Landa 2016, 6). These gaps leave many residents and businesses in unsafe conditions.<br><br>Circular data could help with this situation. While sensor data cannot replace physical inspections, this technology could serve as a useful tool for identifying target areas or... | • Street-Level Video and Still Images<br><br>• Commercial Space Usage | *Public*: In addition to the Department of Buildings, this information could also help groups such as the Small Business First Initiative better locate where there are vacant storefronts and identify a potential cause (e.g., poor maintenance and landlord harassment).<br><br>*Private*: This situational awareness is also valuable to restaurants, bars, and storefronts seeking to monitor their landlords and ensure they comply with building code regulations. Alternatively, it might help them avoid renting properties from bad actors. Per the 2018 NYC Landlord Watchlist, some private landlords accrued nearly 1,500 housing preservation and development violations. |

**Context *(continued)***

eliminating frivolous complaints from their dockets.

By better addressing compliance issues, the city can make Downtown Brooklyn more hospitable to business.

**Risks and Challenges**

*Data security*: As imagery and commercial space usage information could contain sensitive information, data holders should take steps to prevent the possibility of an unwanted disclosure.

*Domain experts*: Except in extreme cases, it might not be readily apparent which properties do and do not meet their building code requirements. As such, a building code expert (or an AI-driven approach developed in coordination with such an expert) would likely be necessary to translate the data into usable intelligence.

**Key Value Proposition:**

Allow officials and businesses to better prevent, mitigate, and deter code violations while also enabling more efficient Department of Buildings complaint investigations

**Proxies for Monetary Value**

A recent report found 2% of New York landlords—those with the highest levels of evictions and housing code violations—cost taxpayers at least $300 million annually (Sen, and Gates 2018). This estimate does not include costs borne by the affected tenants.

**Social Value**

- Improving and Maintaining Infrastructure
- Increasing Access to Affordable Housing
- Fostering Community Wellness
- Stimulating Wage Growth and Employment Creation

**Enabling Conditions**

- Understanding *Causes and Context* contributing to code violations to ensure responses are fit for purpose.

**Sources**:


- Sen, Mandu and Moses Gates. 2018. “The High Cost of Bad Landlords.” Regional Planning Association, October 2018.
- Ferreiro, Julian, Jack Lundquist, Keith Dumanski, and Yixuan Tang. 2018. “Digital Traces of the Predatory Landlord.” Center for Urban Science and Progress. Accessed December 2018. https://cuspcapstones.github.io/Piercing-the-Corporate-Landlord-Veil_2018/index.html.

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| | | **Sources *(continued):*** • Landa, Marjorie. 2016. "Audit Report on the Department of Buildings' Controls over the Processing of Construction Permits," City of New York Office of the Comptroller, June 17, 2016. https://comptroller.nyc.gov/wp-content/uploads/documents/MG15_112A.pdf. |

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| New York City frequently experiences major traffic jams that dampen economic activity and frustrate residents. An improved, real-time understanding of conditions on roadways could inform both public- and private-sector solutions for mitigating traffic impacts—from improved routing of traffic by the city to more responsive navigation platforms developed by companies. Researchers around the world are already exploring how the Internet of Things could enable real-time smart traffic management for cities (Rizwan, Suresh, and Babu 2016).<br><br>Circular data could also be used to identify what parts of the city need more parking and which have too much, allowing.. | • Street-Level Video and Still Images<br><br>• Vehicle Movements | *Public:* As the agency responsible for traffic operations and transportation maintenance, the largest public stakeholder for this use of circular data is the New York City Department of Transportation.<br><br>*Private:* Traffic congestion information has direct relevance for ridesharing companies like Uber, Lyft, Via, and Citi Bike. This information could also supplement the resources of courier delivery services like FedEx and UPS. |

| **Context *(continued)*** | **Key Value Proposition:** | **Social Value** |
|---|---|---|
| business leaders to more effectively use its limited space for maximum economic potential. | Manage traffic congestion for commuters and business deliveries | • Fostering Community Wellness<br>• Stimulating Wage Growth and Employment Creation |
| **Risks and Challenges**<br><br>*Resource Availability:* As many city agencies have constrained budgets, it may be difficult for them to adopt a new means of doing work.<br><br>*Resource Availability and Sustainability:*<br>While officials and business leaders might become aware of where traffic congests, these individuals might lack the political capacity or resources to effectively address the problem. | **Proxies for Monetary Value**<br><br>In 2014, Texas A&M's Transportation Institute estimated delayed truck deliveries in the New York area cost $2.8 billion. Meanwhile, the Partnership for the City of New York estimates that traffic congestion will be a $100 billion drag on the New York metro area's economy over the next five years, with Brooklyn commuters suffering an annual cost of $1,088.<br><br>This estimate includes travel time, excess fuel, operating cost, and total revenue, but not environmental or health consequences. The World Bank estimates poor air quality cost the United States $225 billion in 2013. | **Enabling Conditions**<br><br>• Ensuring that potential collaborators have the requisite *Skills and Expertise* to effectively use circular data<br>• Partnering with other *Data Holders* positioned to help fill data gaps<br><br>**Sources**:<br><br>• Schrank, David, et al. 2015. "2015 Urban Mobility Scorecard." Texas A&M Transportation Institute and INRIX, August 2015. https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015.pdf.<br>• Partnership for the City of New York. 2018. "$100 Billion Cost of Traffic Congestion in Metro New York.", January 2018. http://pfnyc.org/wp-content/uploads/2018/01/2018-01-Congestion-Pricing.pdf. |

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| | | **Sources *(continued)*** • World Bank. 2016. “Air Pollution Deaths Cost Global Economy US$225 Billion.” September 8, 2016.<br>• Shannon, Alex, Fangshu Lin, Rachel Lim Xin Rong, and Sunglyong Kim. 2018. “Vulnerability of Transportation Networks 2.0.” *New York University Center for Urban Science and Progress*. Accessed December 2018. https://cuspcapstones.github.io/Vulnerability-of-Transportation-Networks_2018/.<br>• Rizwan, Patan, K. Suresh, and M. Rajasekhara Babu. 2016. "Real-time smart traffic management system for smart cities by using Internet of Things and big data." In *Emerging Technological Trends (ICETT), International Conference on*, pp. 1-7. IEEE, 2016. |

<table>
<tr>
<td rowspan="2">Context<br><br>Property appraisals are an important but complicated process in New York City. The valuation process depends on a few state-licensed individuals who might be unfamiliar with the surrounding neighborhood. Near identical properties just a few blocks from one another can have dramatically different values (Rendon 2013). The process is a perennial source of frustration for individuals seeking to use their property as collateral for a loan. Others have criticized the process for artificially inflating home prices on behalf of lenders and banks (“Proposed new regulations” 2018).<br><br>In recent years, federal regulators have been exploring ways to make the process faster, less biased, and less costly. One proposal has been to integrate computer algorithms and other new technologies into the process. Several companies, like HouseCanary Inc, are already using AI, algorithms, and drones to value properties.<br><br>Circular data could potentially add similar value. By incorporating information on commercial space usage and nearby assets, data holders can promote grounded estimates.</td>
<td>Data sets Provided by Start-Ups<br><br>• Vehicle Movement<br><br>• Fixed-Street Asset Locations<br><br>• Business and Commercial Space Usage</td>
<td>Beneficiaries<br><br><u>Public:</u> While most directly relevant for property appraisal, similar information could be used by the Department of Finance, which values New York properties every year to help it calculate property tax. Business Improvement Districts (BIDs), including specifically the Downtown Brooklyn BID, would similarly benefit from such improvements to property appraisal capabilities as they seek ways to spur economic activity in target neighborhoods.<br><br><u>Private:</u> Improvements to property appraisal analyses could benefit property owners who are seeking a loan for their businesses. There is also the potential to benefit appraisal companies operating in the Brooklyn area by allowing them to provide their services with a greater degree of accuracy and speed, improving consumer satisfaction while simultaneously reducing costs.</td>
</tr>
<tr>
<td>Key Value Proposition:<br><br>Valuation of properties via electronic appraisals</td>
<td>Social Value<br><br>• Improving and Maintaining Infrastructure<br>• Increasing Access to Affordable Housing<br>• Fostering Community Wellness</td>
</tr>
</table>

| Risks and Challenges | Proxies for Monetary Value | Enabling Conditions |
|---|---|---|
| *Cultural/Institutional Roadblocks*: As the traditional appraisal process is human-driven and often not handled by individuals with data skills, data holders may need to overcome a reluctance on behalf of current stakeholders to incorporate the tool into the process. | Studies of the traditional appraisal process have found a persistent upward bias in appraisals, with properties being appraised at or above the price at which it was previously sold (Nakamura 2010). One 1996 study found fewer than 5% of properties had appraisals lower than their previous price (Man and Megbolugbe 1996). A separate study found a correlation between appraisal bias and more frequent defaults (Nakamura 2010). | • Engaging *Domain Experts* to ensure the accuracy and relevance of circular data for the appraisal process<br><br>**Sources:**<br><br>• Rendon, Jim. 2013. "Understanding the Home Appraisal Process." *New York Times*, January 11, 2013.<br>• "Proposed new regulations would allow homes to be bought and sold through electronic valuations rather than human appraisers."2018. *Daily Mail*, November 29, 2018.<br>• Nakamura, Leonard. 2010. "How Much Is That Home Really Worth? Appraisal Bias and House-Price Uncertainty," *Philadelphia Federal Reserve*, 2010. https://www.philadelphiafed.org/-/media/research-and-data/publications/business-review/2010/q1/brq110_home-worth-appraisal-bias.pdf?la=en. |

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| | | **Sources *(continued)*** <br><br> • Griswold, Bailey, Nina Nurrahmawati, and Te Du. 2018. “Automated Feature Detection from Property Imagery Data.” *New York University Center for Urban Science and Progress*, accessed December 2018. https://cuspcapstones.github.io/Property-Valuation-Tax-Mapping-from-imagery-data_2018/#t1. <br> • Cho, Man, and Isaac F. Megbolugbe. "An empirical analysis of property appraisal and mortgage redlining." *The Journal of Real Estate Finance and Economics* 13, no. 1 (1996): 45-55. |

### Cause-and-Effect Analysis

This vector refers to the value generated from using circular data to better understand the key drivers, reasons for, and consequences of an observed situation. A better understanding of cause and effect is valuable to determine, for instance, the difference between regulatory compliance and actual behavior as well as the correlation between activity in a neighborhood and investment. It can help both business owners and city officials better respond to events.

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| In 2014, the U.S. National Highway Traffic Safety Administration estimated the cost of vehicle crashes to be $871 billion per year (Associated Press 2014). A significant number of these accidents take place in New York. Though fatalities have declined in recent years, the NYPD still reported 20,470 collisions in October 2018. These incidents have real monetary and human costs to the people involved in the incident.<br><br>These incidents also exact costs on nearby businesses. Accidents force road or sidewalk closures, preventing customers and laborers from reaching their destinations. In some cases, accidents and malicious actions can also damage company property. | • Pedestrian Analytics<br>• Street-Level Still Images and Video<br>• Fixed-Street Asset Locations<br>• Vehicle Movements | *Public:* This analysis is directly relevant to city agencies responsible for designing and managing public spaces, such as the Departments of Design and Construction and Parks and Recreation. It is also relevant for law enforcement agencies responsible for responding to accidents and malicious incidents, like the New York Police Department and, potentially, NYC Emergency Management. The information can also support the Department of Transportation and its Vision Zero initiative to eliminate traffic deaths and serious injuries from New York City by 2024—discussed in more detail in this journal by Sahuguet (2019).<br><br>*Private:* This information is also relevant for businesses operating in the vicinity of large public complexes, such as the MetroTech Center, or those near major landmarks with significant foot and automobile traffic, like the Brooklyn Bridge. |
| **Risks and Challenges** | **Key Value Proposition:** | **Social Value** |
| *Poor Decision-Making Due to Faulty Information:* Deciding where to allocate resources for traffic safety can be a literal matter of life or death. Uses of circular data with public safety... | Tracking the relationship between how public spaces are managed and the presence of accidents or malicious behavior | • Improving and Maintaining Infrastructure<br>• Fostering Community Wellness |

| **Risks and Challenges *(continued)*** | **Proxies for Monetary Value** | **Enabling Conditions** |
|---|---|---|
| implications will need to ensure a full understanding of the context in which they are operating to guarantee their interventions have the desired impact and will not have unintended consequences, like redirecting pedestrians to a more vulnerable area or limiting the economic capacity of an area.<br><br>*Data Security*: Understanding patterns of movement can help business owners and city officials improve the resilience of infrastructure. However, the information can also be valuable to malicious actors who may seek to exploit aggregated patterns of movement to cause harm. | In January 2018, the Office of Mayor Bill de Blasio announced it would allocate $50 million toward measures to protect pedestrians at high-risk public spaces from vehicle-ramming attacks, reckless drivers, and other car accidents. | • Defining *Performance Metrics* to establish a target and clear baseline against which to measure progress, such as the City's Vision Zero program<br><br>**Sources**:<br><br>• Associated Press. 2014. "Vehicle Crashes Cost $871 Billion in a Year." *New York Times*, May 29, 2014. https://www.nytimes.com/2014/05/30/business/vehicle-crashes-cost-871-billion-in-a-year.html.<br>• New York Police Department. 2018. "Motor Vehicle Collision Report Statistics Citywide." October 2018. https://www1.nyc.gov/assets/nypd/downloads/pdf/traffic_data/cityacc-en-us.pdf.<br>• De Blasio, Bill. 2018. "Transcript: Mayor de Blasio Announces Extensive Plan to Install Security Bollards to Protect New Yorkers, Tourists, and City's Infrastructure." New York City Hall Press Office, January 2, 2018. |

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| | | **Sources *(continued)*** https://www1.nyc.gov/office-of-the-mayor/news/004-18/transcript-mayor-de-blasio-extensive-plan-install-security-bollards-protect-new.<br>• Sahuguet, Arnaud. 2019. “Circular Data for a Circular City: Value Propositions for Mobility." In *The Circular City Research Journal,* edited by André Corrêa d'Almeida, 99-124. New York: New Lab, 2019. |

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| While the Mayor’s Office for People with Disabilities and other agencies are striving to improve the city’s openness and accessibility, there are many areas that lack services relevant for its residents (e.g., individuals with reduced mobility, the elderly, and individuals with young children who rely on strollers). These gaps make it difficult for residents with particular needs to engage fully with the city and all its economic opportunities. | • Pedestrian Analytics<br>• Street-Level Still Images and Video<br>• Fixed-Street Asset Locations<br>• Business and Commercial Space Usage | *Public:* This work has direct relevance for the Department of Transportation, the Mayor’s Office for People with Disabilities, and the New York City Transit Authority, which oversees programs like Access-a-Ride. The information also has relevance to the Department of Design and Construction, which serves as principal construction project manager, and the Department for the Aging, which supports individuals over the age of 60 who often have unmet needs. |

<table>
<tr>
<td>Context (continued)<br><br>Crowdsourced maps, such as AXS Map, Access Earth, AccessNow, and Wheelmap, show a public interest in helping subsets of the population better navigate the city. Through circular data, businesses can identify areas where specific needs are being unmet and how they can address the situation.</td>
<td></td>
<td>Beneficiaries (continued)<br><br><u>Private:</u> As discussed, businesses located in difficult to reach locations are unlikely to be frequented by customers with reduced mobility. As such, businesses located in or near structures (e.g., subway stations and older buildings) that do not meet the standards set by the Americans with Disabilities Act can benefit from this information.<br><br>In addition, this data could also be used by businesses who want to specifically target the needs of an underserved population. Companies like Uber and Lyft are increasingly looking at providing paratransit services (Urban 2017).</td>
</tr>
<tr>
<td rowspan="2">Risks and Challenges<br><br><u>Intermediaries:</u> While there may be an interest in using circular data to complement existing efforts to expand accessibility, many of the groups spearheading the initiative have limited budgets and capabilities. As such, it may be necessary to identify possible intermediaries who can determine whether outputs reach the target population.</td>
<td>Key Value Proposition:<br><br>Understanding the causes and effects of reduced mobility among specific demographics and how they could be addressed</td>
<td>Social Value<br><br>• Improving and Maintaining Infrastructure<br>• Promoting Environmental Safety<br>• Fostering Community Wellness</td>
</tr>
<tr>
<td>Proxies for Monetary Value<br><br>A study by the Rudin Center at New York University found that Access-a-Ride trips that began or ended near subway stations that did not meet Americans with Disabilities Act requirements cost the city $258 million in 2015. Infrastructure improvements in</td>
<td>Enabling Conditions<br><br>• Identifying additional <u>Collaborators</u> and <u>Domain Experts</u> capable of providing additional intelligence and/or supporting engagement with affected communities</td>
</tr>
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| | **Proxies for Monetary Value *(continued)***<br><br>relevant areas could potentially decrease long-term costs while making the city more economically accessible to residents with disabilities. | **Sources:**<br><br>• Blair-Goldensohn, Sasha. 2017. “New York Has a Great Subway if You’re Not in a Wheelchair.” *New York Times*, March 29, 2017. https://www.nytimes.com/2017/03/29/opinion/new-york-has-a-great-subway-if-youre-not-in-a-wheelchair.html?module=inline.<br>• Hamraie, Aimi. 2018. “A Smart City is an Accessible City,” *The Atlantic*, November 6, 2018. https://www.theatlantic.com/technology/archive/2018/11/city-apps-help-and-hinder-disability/574963/.<br>• Urban, Amanda. 2017. “Could Uber and Lyft push to make paratransit efficient and affordable?” MobilityLab, July 28, 2017. https://mobilitylab.org/2017/07/28/uber-lyft-push-make-paratransit-efficient-affordable/.<br>• Kaufman, Sarah, Joanna Simon, Calloway Hope Aboaf. 2017. “Bringing Innovation to Paratransit.” *Rudin Center*, December 2017. https://wagner.nyu.edu/rudincenter/2017/12/new-report-bringing-innovation-paratransit. |

| Context | Data sets Provided by Start-Ups | Beneficiaries |
|---|---|---|
| Tourism and recreation are an important part of the New York economy but are characterized by seasonality. The highest concentrations of visitors arrive in relatively short periods of the year (e.g., New Year's Eve, the spring holiday season). Amid shifts during "peak season," high tourism can harm profitability at local businesses through lost opportunities due to congestion and overbooking, or reduce service quality, which can have long-term reputational effects. In "off-seasons," companies can lose money when business is slow. While there are some existing mechanisms to predict turnout, real-time data is scarce.<br><br>Companies often have imperfect ways of understanding this phenomenon based around past experiences and "gut feelings" about the future. Managers make staffing and resource decisions based upon them. However, seasonality can be measured through the use of data, leading to more effective management (Sutcliffe and Sinclair. 1980). Incorporating data from circular city partners could potentially further refine and enhance this data-driven work, allowing businesses to see seasonal... | • Street-Level Still Images and Video<br><br>• Pedestrian Analytics<br><br>• Vehicle Movements<br><br>• Business and Commercial Space Usage | *Public:* As the City's official marketing and tourism unit, the quasi-government agency NYC & Company could use this data to enhance the work produced by its Research Unit, which informs citywide marketing and strategic planning decisions. The information is also relevant for the Department of Small Business Services, which could use it to help new businesses navigate through holiday seasons, and the Department of Sanitation, which could use the information to prioritize garbage collection in areas more likely to experience unusually high traffic rates.<br><br>*Private:* Almost all businesses are affected, to some degree, by seasonality. However, seasonality is a particularly significant issue for the hospitality and recreation industries. This data analysis also has value for retailers, who could use the information to determine staffing and hours during events like "Black Friday." |

<table>
<tr><td>Context (continued)<br><br>impacts on themselves and competitors with more granularity.</td><td>Key Value Proposition:<br><br>Identifying seasonal impacts on tourism flows for better resource planning and allocation</td><td>Social Value<br><br>• Stimulating Wage Growth and Employment Creation</td></tr>
<tr><td rowspan="2">Risks and Challenges<br><br>Entrenching Power Asymmetries: Large corporations, including those based outside of the city, could benefit from seasonal circular data just as smaller companies in the city can. Certain steps will likely be necessary to ensure that the benefits of such analytical capabilities spread beyond dominant industry players.</td><td rowspan="2">Proxies for Monetary Value<br><br>New York City’s economy relies heavily on tourism and recreation. In 2016, New York City received $43 billion in direct visitor spending from tourists (NYC & Company 2017). A greater understanding of how spending patterns and population change seasonally can improve businesses’ capacity to capitalize on the tourism industry.</td><td>Enabling Conditions<br><br>Engaging relevant Intermediaries, such as chambers of commerce or business associations, to bring relevant private sector actors to the table<br><br>Tapping into relevant Domain Expertise to gain insight into any industry-specific considerations relevant to the assessment of seasonal impacts</td></tr>
<tr><td>Sources:<br><br>• Sutcliffe, Charles MS, and M. Thea Sinclair. 1980. "The measurement of seasonality within the tourist industry: an application to tourist arrivals in Spain." Applied Economics 12, no. 4 (1980): 429-441. https://www.tandfonline.com/doi/pdf/10.1080/00036848000000004.</td></tr>
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| | | **Sources *(continued)*** <br><br> • NYC & Company, 2017. "NYC Travel & Tourism Overview." December 2017. https://assets.simpleviewcms.com/simpleview/image/upload/v1/clients/newyorkcity/NYC_Company_NYC_Travel_Tourism_OverviewEW_dcf2eeb0-2f7b-4dfa-be7f-c4721564b60b.pdf. |

### Prediction

This vector refers to the value generated from using circular data for improved forecasting and assessments on future risks, needs, and opportunities. Prediction can enable public and private organizations to better respond to a variety of business and economic development topics ranging from zoning and construction to investment and insurance.

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| Major events frequently interfere with the regular operation of local residents and businesses. Residents of Downtown Brooklyn, home of various community events and host of cultural events at sites like the Barclays Center, are particularly aware of this fact. Businesses must often accommodate disruptions caused by conventions, concerts, and sporting events. <br><br> Some research suggests "public sector marketing strategies [can] utilize events... | • Pedestrian Analytics <br><br> • Street-Level Still Images and Video <br><br> • Fixed-Street Asset Locations <br><br> • Vehicle Movements | Public: The Mayor's Office of Citywide Event Coordination and Management is the main body providing oversight of event-permitting activities and coordination of street activities in Brooklyn. By incorporating circular data, officials in the office could better assess the potential impact of street closures and additional congestion on the affected area. <br><br> *Private:* The information could also be used by businesses to help them create a plan of... |

**Context *(continued)***

strategically to bring long-term economic and social benefits to the location and its community (Pugh and Wood 2004, 1). Circular data has the potential to help Downtown Brooklyn realize that promise while mitigating costs. By understanding how events affect the city in advance, business owners can change their operations and staffing.

**Risks and Challenges**

*Causes and Context:* To understand why certain patterns of behavior are emerging, data holders will need to understand the environment they are observing, including a baseline of conditions during periods when events are not occurring. Identifying such a baseline can be challenging, and analysis undertaken without this background knowledge will be difficult to evaluate.

**Key Value Proposition:**

Predicting impact of events on market conditions

**Proxies for Monetary Value**

The New York City Economic Development Corporation estimates that the 2018 Opening Day Game for the New York Yankees at Yankee Stadium in the Bronx generated an economic impact of $11.9 million for the city, with $5.2 million being the indirect impact of spending by companies who benefit from higher visitor expenditures. Although Barclay's Center can seat only 19,000 compared to Yankee Stadium's 54,000 seat capacity, the distributed economic impact of events is evident.

**Beneficiaries (*continued*)**

action regarding future events so they can limit potential losses and maximize the opportunities presented by these events.

**Social Value**

- Improving and Maintaining Infrastructure
- Fostering Community Wellness
- Stimulating Wage Growth and Employment Creation

**Enabling Conditions**

Ensuring *Refinement* of the problem definition to focus on granular, actionable, and quantifiable parts of the market

Creating *Feedback Loops* allowing businesses and residents affected by local events to provide additional input and intelligence

**Sources:**


- Pugh, Craig and Emma H. Wood. 2004."The strategic use of events within local government: A study of London Borough Councils." *Event Management*, Vol. 9, 1-2 (January), pp. 61–71.

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| | | **Sources *(continued)*** https://www.researchgate.net/publication/233635992_The_strategic_use_of_events_within_local_government_A_study_of_London_Borough_Councils.<br>• Hogrebe, Anthony and Chris Singleton. 2018. “NYCEDC Announces Economic Impact of $11.9 Million for 2018 Yankees Opening Day Game.” New York City Economic Development Corporation, April 3, 2018. https://www.nycedc.com/press-release/nycedc-announces-economic-impact-119-million-2018-yankees-opening-day-game.<br>• Crompton, John L., and Stacey L. McKay. 1994. "Measuring the economic impact of festivals and events: Some myths, misapplications and ethical dilemmas." *Festival Management and Event Tourism* 2, no. 1 (1994): 33-43. |

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| According to FEMA, 40 percent of small businesses never reopen after a disaster and an additional 25 percent fail within a year (McKay 2018). To survive catastrophes, companies need to be prepared.<br><br>This preparation is difficult without awareness of the risks facing the company or vulnerabilities inherent in the area. Through real-time data, officials can better understand how they will be affected by events and develop emergency plans that mitigate their impact. | • Pedestrian Analytics<br>• Street-Level Still Images and Video<br>• Fixed-Street Asset Locations<br>• Vehicle Movements<br>• Business and Commercial Space Usage | *Public*: This data is especially relevant for New York City Emergency Management, which is responsible for managing and overseeing the city's emergency plans, as well as the New York Police Department and New York Fire Department, which often serve as first responders in sudden emergency events.<br><br>*Private*: As shown by Hurricane Sandy in 2012, businesses in low-lying areas or near the shoreline are particularly vulnerable to severe weather events. This information could help a wide range of businesses based in places like Downtown Brooklyn, Red Hook, and Coney Island develop their own emergency plans and determine whether to invest in structural defenses or response strategies. |
| **Risks and Challenges** | **Key Value Proposition:** | **Social Value** |
| *Cultural / Institutional Roadblocks:* Given the complex analysis required to reach these conclusions and the irregularity of severe events in the Downtown Brooklyn area, it may prove difficult to integrate circular data analyses into existing workflows. | Predict impact of disaster and catastrophic events | • Improving and Maintaining Infrastructure<br>• Stimulating Wage Growth and Employment Creation<br>• Fostering Community Wellness |

| | | |
|---|---|---|
| | **Proxies for Monetary Value**<br><br>Hurricane Sandy is estimated to have cost New York City $19 billion (PlaNYC, 2013). These costs came from damages across the five boroughs that led to protracted, and sometimes permanent, business closures. | **Enabling Conditions**<br><br>Ensuring *Domain Experts*, like emergency planners, are engaged in the design of a circular data use case |
| | | **Sources**:<br><br>● McKay, Jim. 2018. “Small Businesses Are a Vital Part of Community Resiliency but Often Overlook Vulnerabilities.” *Emergency Management*, July 26, 2018.<br>● PlaNYC. 2013. “A Stronger, More Resilient New York.” The City of New York, June 11, 3013.<br>● He, Hans, Yu Chen, Chenrui Zhang, Emily Padvorac. 2018. “Piercing into New York City Flood Risk Affected Housing Market.” Accessed December 2018. https://ch3183.wixsite.com/capstone2018. |

**Context**

Businesses face serious problems in reaching their customers and deciding where they should be based. This can make it more difficult to remain in business and impede store owners from creating touchpoints for tailored advertising and shopping.

Through circular data, landlords and retailers can better understand who might have interest in their spaces, allowing storefronts to be filled sooner or preventing them from becoming vacant entirely. In Durham, North Carolina, a local nonprofit installed cameras in downtown intersections to collect data on car and foot traffic patterns to “provide better data to retailers — and potential retailers — about the pedestrian traffic” (Vaughan 2018). In New York, the NYU bookstore used sensor data to adjust staffing, opening hours, and sales associate training.

**Risks and Challenges**

*Privacy Concerns:* Even with privacy-preserving mechanisms in place, risks and perceived risks related to the accidental disclosure of personally identifiable information could impact efforts to leverage circular data on pedestrian movements and activity.

**Data sets Provided by Start-Ups**

- Pedestrian Analytics
- Street-Level Still Images and Video
- Fixed-Street Asset Locations
- Business and Commercial Space Usage

**Key Value Proposition:**

Improving the likelihood of businesses to thrive in a given neighborhood and to reach target audiences with their marketing efforts

**Proxies for Monetary Value**

Advertising in Brooklyn is expensive. Though specific prices vary, a subway entrance ad in the New York area can cost $3,000 a month . Advertising in a subway train, covering 25...

**Beneficiaries**

*Public*: This information has potential value for the Department of Small Business Services and New York City Office of Workforce Development, which could use the data as a case study to assist small businesses and help workers better understand the environment in which they operate.

*Private*: As evidenced by the context, the most obvious users for this information are retailers and shopping complexes, which can use the information to better understand how individuals move through their locations and better meet the needs of those individuals.

**Social Value**

- Improving and Maintaining Infrastructure
- Fostering Community Wellness
- Stimulating Wage Growth and Employment Creation

**Enabling Conditions**

Undertaking *User Research* to gain a greater upfront understanding of a business’s target audience could lead to more strategic analyses

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|---|---|---|
| | **Proxies for Monetary Value *(continued)***<br><br>percent of the interior ad space, can cost $44,000 a month. Street-lamp banners are $360 per banner (Kosofsky Glassberg n.d.). | **Sources:**<br><br>● Vaughan, Dawn Baumgartner. 2018. "People-Counting Cameras Are Watching the Streets of Durham, N.C." *The Durham Herald-Sun*, July 6, 2018. http://www.govtech.com/data/People-Counting-Cameras-Are-Watching-the-Streets-of-Durham-NC.html.<br>● "NYU Bookstore Gained Deep Insights Into Success Of Retail Operations With Data from Motionloft," *Motionloft*, October 6, 2017, https://info.motionloft.com/hubfs/assets/nyu-case-study.pdf?submissionGuid=604d4ffe-d0d1-45b4-8788-d00c168ec0e9<br>● Kosofsky Glassberg, Brooke. n.d. "New Ad City." *New York*. http://nymag.com/nymetro/news/people/columns/intelligencer/15156/.<br>● Waters, Stu. 2018. "Motionloft Shopper Data Helps Credo Beauty Optimize the Retail Experience." Accessed December 2018. https://app.hubspot.com/documents/2953336/view/15090503?accessId=a3f872. |

### Impact Assessment

Impact assessment is the value generated from using circular data to understand which, whether, and how investments and initiatives contribute to neighborhood economies. It also allows individuals to evaluate obstacles to innovation and growth more effectively and rapidly as well as allowing decision-makers to tweak, adjust, and (when necessary) redirect scarce resources in ways that extend the benefits of these interventions more widely, enabling more return on investment or preventing costs.

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| New York City is undergoing a period of historic growth. According to the Mayor's Office, the city has outperformed the nation in employment growth in almost every sector. Unemployment has fallen to 4 percent. An estimated 60 million people visited the city in 2016.<br><br>Some of these achievements are the result of city and business-led investments to make New York a more economically resilient and diverse place. The New York City Economic Development Corporation (EDC), the non-profit charged with spurring economic development on the city's behalf, plans to spend $4.1 billion between 2018 and 2022 to further these goals.<br><br>Groups like EDC use various means to determine where to direct this money, but this decision-making process could benefit from the introduction of circular data. In New Orleans, the Downtown Development… | • Pedestrian Analytics<br><br>• Street-Level Still Images and Video<br><br>• Fixed-Street Asset Locations<br><br>• Vehicle Movements<br><br>• Business and Commercial Space Usage | *Public*: This usage has particular potential value for EDC. By assessing the impact of its investments, the organization can determine what projects do and do not work, allowing it to make better decisions about future investments and avoid biased judgments.<br><br>*Private*: The Brooklyn Chamber of Commerce and other business groups based around the city could use the information to advocate on behalf of their members. The information could also be useful for large companies seeking to relocate or invest in Brooklyn, allowing them to assess what the impact of their presence would be and avoid exacerbating inequalities. |

<table>
<tr>
<td>Context (continued)<br><br>District (DDD) turned to the company Motionloft to help them increase pedestrian traffic and attract high-quality retailers. The company installed sensors that produced data that helped officials convince companies to invest in the region.</td>
<td>Key Value Proposition:<br><br>Measuring the impact of investments in specific neighborhoods on economic development objective</td>
<td>Social Value<br><br>● Fostering Community Wellness<br>● Stimulating Wage Growth and Employment Creation</td>
</tr>
<tr>
<td rowspan="2">Risks and Challenges<br><br><u>Entrenching Power Asymmetries:</u> The analysis of circular data can lead to greater investment in under-served areas that are ripe for responsible development efforts. However, those investments could also be put toward more economically secure areas, perpetuating inequity and missing opportunities for spurring more transformative growth.</td>
<td rowspan="2">Proxies for Monetary Value<br><br>For fiscal year 2019, the New York City Economic Development Corporation plans to invest in 143 projects in Brooklyn, an investment totaling $781.2 million. This is the second-largest investment among the five boroughs.</td>
<td>Enabling Conditions<br><br>Defining <u>Data Stewardship</u> objectives and processes to ensure circular data-driven investment use cases are aligned with the missions and core beliefs of collaborators</td>
</tr>
<tr>
<td>Sources:<br><br>● Glen, Alicia. 2017. “New York Works.” Office of the Mayor of New York, June 15, 2017.<br>● Ali, Aliya. 2018. “Report of the Finance Division on the Fiscal 201 Preliminary Budget and the Fiscal 2018 Preliminary Mayor’s Management Report for the Economic Development Corporation.” March 9, 2018. https://council.nyc.gov/budget/wp-content/uploads/sites/54/2018/03/FY19-Economic-Development-Corporation.pdf.</td>
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| | | **Sources *(continued)*** • "Revitalizing Retail in Downtown New Orleans." 2018. Motionloft. Accessed on December 10, 2018. https://app.hubspot.com/documents/2953336/view/15089299?accessId=f61a92.<br>• New York City Department of City Planning. 2018. "The Geography of Jobs." July 2018. https://www1.nyc.gov/assets/planning/download/pdf/about/dcp-priorities/data-expertise/nyc-geography-jobs-0718.pdf. |

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| Downtown Brooklyn is a heavily urbanized space. However, green space is essential for making areas liveable as they provide places for physical activity, recreation, and ecological diversity.<br><br>While past research suggests a clear relationship between green spaces and property value, with the assumption that residents are more willing to pay for the perceived benefits of it, recent research suggests a more complicated relationship (Catrakilis 2015). It also suggests that people... | • Pedestrian Analytics<br><br>• Street-Level Still Images and Video<br><br>• Fixed-Street Asset Locations | *Public*: Understanding how the public interacts with parks and other green spaces would help the Department of Parks and Recreation determine where to prioritize resources to maximize the quality of life in and around their domain. The information might also help the Department of Small Business Services provide more targeted assistance to local entrepreneurs about where to base their companies and how to make the most use out of their location. The Department of City Planning, with its responsibility for reviewing ... |

**Context *(continued)***

perceive and interact differently with these spaces depending on context.

Understanding how, where, and when green space benefits residents has clear importance for businesses, as it impacts everything from the price of their property to the foot and vehicle traffic their storefront can expect. Through the use of circular data, business leaders and public officials can more accurately measure the value and impact of park and beautification projects. They can then use these measurements to make informed decisions that benefit their organization.

**Risks and Challenges**

*Resource Availability:* While there might be an interest in how data can reveal new opportunities around parkland and beautification projects, many of the organizations responsible for these issues have constrained resources that make it difficult to take on new processes and ways of doing business. It might be necessary to establish internal or external intermediaries to fill this role in their stead.

**Key Value Proposition:**

Assessing impacts of neighborhood beautification projects and park maintenance on property values, area livability, and community wellness

**Beneficiaries *(continued)***

land use and overseeing the built environment, might also exploit circular data to supplement its existing processes.

*Private*: Circular data usage also has relevance for businesses based around city-managed parks like Trinity Park to identify how city agencies are managing the spaces. Officials can also use the information to identify where improvements can be made and, with public or private partners, invest in art installations, pavilions, and other fixed objects that might attract foot traffic.

**Social Value**

- Fostering Community Wellness
- Improving and Maintaining Infrastructure
- Increasing Access to Affordable Housing

| | | |
|---|---|---|
| | **Proxies for Monetary Value**<br><br>Per the New York State Department of Environmental Conservation, trees and other plants can add up to 10 percent to a property's value. Meanwhile the New York Department of Parks and Recreation is estimated to spend $564,522,000 for the 2018 fiscal year | **Enabling Conditions**<br><br>Defining *Performance Metrics* upfront could help ensure agreement around what is meant by key terms and objectives like, for example, "livability" and "wellness"<br><br>Engaging *Domain Expertise* early in the process could also provide a deeper understanding of important factors like local infrastructure and real estate |
| | | **Sources:**<br><br>● Catrakilis, Natasha. 2015. "Literature Survey: Green Space and Property Values." Duke University Urban Economics. April 28, 2015. https://sites.duke.edu/urbaneconomics/?p=1441.<br>● Kwiek, Lexie. 2018. "Trees provide beautification, health benefits and increased property values." *Oswego County News Now,* April 7, 2018. http://www.oswegocountynewsnow.com/oswego_county_homes/trees-provide-beautification-health-benefits-and-increased-property-values/article_4fcc118c-3a9a-11e8-8f86-f3a585c23fa9.html. |

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|---|---|---|
| | | **Sources *(continued)*** • Hartzog, Melanie. 2018. "The City of New York Financial Plan Fiscal Years 2018 – 2022." *Mayor's Office of Management and Budget*, February 2018.<br>• Olavsrud, Thor. 2013. "New York Turns to Big Data to Solve Big Tree Problem." *CIO,* June 4, 2013. https://www.cio.com/article/2385245/data-management/new-york-turns-to-big-data-to-solve-big-tree-problem.html. |

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| Downtown Brooklyn is a vibrant and rapidly growing part of the city and with this economic interest comes the need for the construction of new infrastructure to meet the needs of the population and surrounding businesses. In 2017, the Department of Buildings issued almost 43,000 construction permits in Brooklyn (Hu 2018).<br><br>However, protracted construction can cause serious disruptions to how companies operate. Noise, dust, barricades, and traffic jams can drive customers away. Street closures can make storefronts… | • Pedestrian Analytics<br>• Fixed-Street Asset Locations<br>• Vehicle Movements<br>• Business and Commercial Space Usage | <u>*Public:*</u> The information is directly relevant for the Department of Buildings, which manages safety and security around building construction sites as well as responding to accidents. It is similarly relevant for the Department of Transportation, which oversees street and roadway construction, and Department of Small Business Services, which could use the information to better respond to the needs of struggling stores afflicted by protracted construction.<br><br><u>*Private:*</u> The information has additional relevance for businesses trying to operate… |

**Context *(continued)***

difficult or impossible to access. These developments harm local businesses and can undermine the economic stability of a neighborhood.

Through the use of circular data, business owners can more accurately measure the consequences of construction, helping them seek aid from public authorities, relocate their organization, or change how they manage and staff their location.

**Risks and Challenges**

*Performance Metrics:* In assessing the impact of construction, corporations and business groups have often pointed to declines in profit or closures. However, correlation is not causation. Declines in profit can be due to any number of factors, including a decline in quality, the arrival of new competition, or seasonality. Data holders face some of the same issues. In consultation with their target consumer, they must decide what constitutes their baseline and how they plan to measure impact.

**Key Value Proposition:**

Estimating the impact of construction on local businesses

**Proxies for Monetary Value**

In 2010, store owners on Second Avenue between 63rd and 96th street estimated that business declined between 25 and 50 percent as a result of the Second Avenue subway construction project (Berger 2010). The Manhattan Chamber of Commerce, meanwhile, counted 29 newly shuttered shops along the stretch.

In Portland, worries about the effects of a similar subway construction project led public officials to offer affected businesses low-interest loans ranging between $5,000 and $25,000 (Browne et al. 2009).

**Beneficiaries *(continued)***

near active major construction (or anticipated construction) in the Downtown Brooklyn area. In December 2018, active construction covered over 193,000,000 square feet across the city.

**Social Value**

- Improving and Maintaining Infrastructure
- Fostering Community Wellness
- Stimulating Wage Growth and Employment Creation

**Enabling Conditions**

Examining the *Causes and Context* surrounding a construction project to ensure the accuracy of causal linkages uncovered through circular data uses

**Sources:**


- Hu, Winnie. 2018. “A Real-Time Map Tracks the Building Frenzy That’s Transforming New York.” *New York Times,* August 21, 2018. https://www.nytimes.com/2018/08/21/nyregion/construction-map-buildings-department.html?smid=tw-nytmetro&smtyp=cur.

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| | | **Sources *(continued)*** • Berger, Joseph. 2010. "Subway Work on 2nd Avenue Hobbles Stores." *New York Times,* October 4, 2010. https://www.nytimes.com/2010/10/05/nyregion/05second.html.<br>• Department of Buildings. 2018. "NYC Active Major Construction." Accessed on December 13, 2018. https://www1.nyc.gov/assets/buildings/html/nyc-active-major-construction.html.<br>• Browne, Daniel, Mark Woltman, Dana Brodsky, and Asa Craig. 2009. "The Subway Shaft: How Second Avenue Subway Construction Hurts Businesses in its Path." Office of the New York City Public Advocate, December 2009. http://www.nyc.gov/html/records/pdf/govpub/moved/pubadvocate/SecondAveReportFinalWeb.pdf. |

**Context**

Brooklyn is a large metropolitan area composed of various groups with sometimes competing interests. While public officials and business leaders should strive to promote public policy in a way that promotes fair and equitable growth, the ways to achieve this goal are not always self-evident. Extensive analysis is sometimes needed to ensure that a particular policy worked as intended.

Circular data offers another way for city officials and business leaders to study a policy's impact. By viewing various sources of data, holders can assess whether a specific economic development policy led to more business openings and closures or if it benefited the intended targets.

**Risks and Challenges**

*Cultural/ Institutional Roadblocks*: Business groups and public agencies affected by certain policies may be reluctant to add relatively new assessment mechanisms into their toolkits.

**Data sets Provided by Start-Ups**

- Pedestrian Analytics
- Fixed-Street Asset Locations
- Vehicle Movements
- Business and Commercial Space Usage

**Key Value Proposition:**

Understanding the impact of economic development policies on business openings and closures

**Proxies for Monetary Value**

The MetroTech Business Improvement District (BID), one of three BIDs that cover the Downtown Brooklyn area, spent $3,356,819 on streetscapes and beautification to increase foot traffic to businesses in the area...

**Beneficiaries**

*Public:* The Department of Buildings, Department of Small Business Services, Office of Workforce Development, Business Integrity Commission, Independent Budget Office, and Economic Development Corporation all play a role in developing and assessing economic development policies.

*Private:* As a major source of loans, this information can help banks and other financial institutions with a large presence in Brooklyn—such as JPMorgan Chase, Capital One, and TD Bank—seeking to avoid bad investments.

**Social Value**

- Improving and Maintaining Infrastructure
- Fostering Community Wellness
- Stimulating Wage Growth and Employment Creation

**Enabling Conditions**

Longer term *Resource Availability and Sustainability* could be necessary to assess impacts over time, especially as development policies continue to evolve and accumulate

| | | |
|---|---|---|
| | **Proxies for Monetary Value *(continued)***<br><br>and spur new business creation and retention (New York City Small Business Services 2017). A greater understanding of shifts in local business openings and closures can provide insight into the return on those annual investments. | **Sources:**<br><br>● New York City Small Business Services. 2017. "NYC Business Improvement District Trends Report FY17." 2017. https://www1.nyc.gov/assets/sbs/downloads/pdf/neighborhoods/fy17-bid-trends-report.pdf. |

### Ecosystem Support

Ultimately, economic vitality within a community, neighborhood, or city depends on maintaining a healthy ecosystem—a set of related and interdependent systems such as business districts, education systems, traffic systems, health provision systems, among others.

Circular data's greatest value may lie in enabling a healthy ecosystem by making visible these interdependencies and the way changes in one system can improve or undermine other parts of the ecosystem. Economic development isn't just about increasing jobs or creating new businesses. The purpose of economic development is to help communities become stronger by making sure that the economic part of the ecosystem is fulfilling its role adequately. This project, therefore, also assesses the value of data by seeking to understand how circular data can help facilitate the health of the ecosystem at large.

| **Context** | **Data sets Provided by Start-Ups** | **Beneficiaries** |
|---|---|---|
| Each day, institutional and residential homes in New York City produce almost 12,000 tons of garbage, of which Brooklyn provides about 3,700 tons (New York City Department of Sanitation 2017). This trash, as discussed in this journal by Nilda Mesa (2019), provides breeding for rats, contaminates the water supply, and undermines community bonds. Each of these harm public... | ● Street-Level Still Images and Video<br><br>● Fixed-Street Asset Locations<br><br>● Business and Commercial Space Usage | *Public*: The clearest public stakeholder for this information is the Department of Sanitation, which could use the data to improve the efficiency and effectiveness of its trash collection processes, prioritizing certain areas depending on how much garbage needs to be collected.<br><br>*Private*: The information is also relevant for commercial trash... |

<table>
<tr>
<td rowspan="2">Context (continued)<br><br>health. In response to some of these costs, Mayor de Blasio has called for zero waste by 2030.<br><br>Garbage has real economic consequences for businesses as well. Street refuse can suppress pedestrian traffic and make destinations less attractive. In Brooklyn, a change in waste management was spurred by residents “embarrassed to have relatives visit them because of the garbage at the corners” (Berger 2011).<br><br>While the amount of garbage produced in the city is on the decline, it remains a significant issue for the city and its residents (Department of Sanitation, 2017). Circular data could be useful in improving trash management.</td>
<td></td>
<td>Beneficiaries (continued)<br><br>haulers who service businesses in New York, as the information could lower their costs and increase their ability to retain customers. As previously discussed, improved trash collection is also a benefit for businesses, particularly food services (who produce the most trash), as it removes a deterrent for customers.</td>
</tr>
<tr>
<td>Key Value Proposition:<br><br>Improving the efficiency of commercial and public trash collection to beautify neighborhoods and remove physical obstructions for pedestrians</td>
<td>Social Value<br><br>• Improving and Maintaining Infrastructure<br>• Promoting Environmental Safety</td>
</tr>
<tr>
<td>Risks and Challenges<br><br><u>Causes and Context:</u> The accumulation of trash is a symptom of a diversity of underlying, interconnected challenges. While improved garbage collection practices are likely to provide value, making a meaningful dent in addressing the root causes of high levels of trash will likely require even more complex and multi-stakeholder solutions.</td>
<td>Proxies for Monetary Value<br><br>Garbage is a serious drag on the City’s economy. Compared to Washington, D.C., which pays $182 for each ton of garbage collected, New York pays $251 a ton. According to one member of the Citizens Budget Commission, “New York City’s system for collecting and disposing of garbage creates exceptionally high costs and diminishes resources for other priorities”</td>
<td>Enabling Conditions<br><br>Securing a commitment to <u>Responsiveness</u> among actors responsible for acting upon the insights drawn from circular data, especially if and when those insights differ from well-established legacy processes</td>
</tr>
</table>

| **Risks and Challenges *(continued)*** | **Proxies for Monetary Value *(continued)*** | **Sources:** |
|---|---|---|
| *Skills and Expertise*: Groups responsible for trash collection may lack the sophisticated data science expertise that would allow them to directly manipulate and make use of circular data. As such, additional effort, e.g., engaging intermediaries or developing circular data-driven knowledge products or dashboards, might be required to make the information relevant and usable. | (Short 2014). Similar costs are likely accrued by commercial entities, who must pay commercial haulers to dispose of their garbage. | • Mesa, Nilda. 2019. "Circular Data for a Circular City: Value Propositions for Resilience and Sustainability." In *The Circular City Research Journal,* edited by André Corrêa d'Almeida, 127-140. New York: New Lab, 2019.<br>• New York City Department of Sanitation. 2017. "Annual Report: New York City Curbside and Containerized Municipal Refuse and Recycling Statistics."December 2017.<br>• Berger, Joseph. 2011. "Fighting Litter in Brooklyn by Getting Rid of the Litter Baskets."*New York Times*, June 2, 2011. https://www.nytimes.com/2011/06/03/nyregion/brooklyn-tries-fighting-trash-by-removing-baskets.html.<br>• "ONENYC: Mayor de Blasio's Zero Waste Challenge Wraps Up With Thousands Of Tons Of Waste Diverted From Landfill and Incineration." New York City Hall Press Office, July 11, 2016. |

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|---|---|---|
| | | **Sources *(continued)*** • Short, Aaron. 2014. "New York is top of the heap in garbage-hauling costs." *New York Pos*t, May 24, 2014. https://nypost.com/2014/05/24/new-york-is-top-of-the-heap-in-garbage-hauling-costs/.<br>• Binst, Jochem. 2018. "Arcadis Helps New York City Develop Plan to Reduce Trash Truck Traffic by 63 Percent." Arcadis, December 11, 2018. https://www.arcadis.com/en/global/news/latest-news/arcadis-helps-new-york-city-develop-plan-to-reduce-trash-truck-traffic-by-63-percent/2228402/#.<br>• Department of Sanitation. 2017. "2017 NYC Waste Characterization Study." https://dsny.cityofnewyork.us/wp-content/uploads/2018/04/2017-Waste-Characterization-Study.pdf. |

**Context**

The last few years have seen substantial rent growth across New York City, driven in part by renewed economic interest in the city and partly by an influx of new residents. While the city has sought to take advantage of this increase in wealth, pre-existing inequalities have also been exacerbated. Many residents have been forced out of their neighborhoods. Local businesses find it increasingly difficult to stay afloat amid new competition that specifically targets new residents.

Amazon's intention to build a second headquarters in Queens has increased such concerns. While the investment is a potential economic boon, many fear it will further gentrify the city and make it difficult for local businesses to compete and for local residents to thrive.

**Data sets Provided by Start-Ups**

- Street-Level Still Images and Video
- Fixed-Street Asset Locations
- Business and Commercial Space Usage

**Beneficiaries**

*Public*: The New York City Department of Housing Preservation and Development, as the agency responsible for developing and maintaining affordable housing within the city, could use this information to assess its progress in making affordable housing available. Increasing the availability of affordable housing is also a key stated priority of the Mayor Bill De Blasio administration.

*Private*: This information could also prove valuable for local, long-established businesses operating in the Brooklyn area, particularly those facing steady increases in rent or a rapidly declining consumer base. Such information might be used to inform new business strategy development, relocation, or advocacy efforts.

**Key Value Proposition:**

Assessing the impact of major investments and demographic changes on neighborhood cohesion (i.e., assessing and responding to gentrification)

**Social Value**

- Increasing Access to Affordable Housing
- Fostering Community Wellness

**Risks and Challenges**

*Privacy Concerns:* Efforts to increase neighborhood cohesion and an accordant consideration of demographic changes could lead to privacy concerns related to both personally identifiable...

**Proxies for Monetary Value**

New York University's Furman Center found a rapid decline in the number of rental units available to low-income families between 2000 and 2014. Much...

**Enabling Conditions**

Creating *Feedback Loops* to ensure that residents and others impacted by neighborhood cohesion can provide input into any circular...

| **Risks and Challenges** ***(continued)*** | **Proxies for Monetary Value** ***(continued)*** | **Enabling Conditions** ***(continued)*** |
|---|---|---|
| information and demographically identifiable information—even aggregate and anonymized data can provide undue visibility into the behavior of certain demographic groups. | of this decline took place in Brooklyn, where the neighborhoods of Williamsburg and Greenpoint saw an average increase in rent of 78.7%. | data-driven interventions<br><br>**Sources**:<br><br>● Zuk, M. and K. Chapple. 2015. Urban Displacement Project. http://www.urbandisplacement.org/.<br>● Hambardzumyan, Ruben, Dana Chermesh Reshef, Gerardo Rodriguez Vazquez, and Hao Xi. 2018. “Urban Displacement Project for the New York Metro Region.” New York University Center for Urban Science and Progress. Accessed December 2018. http://www.udpny.org/.<br>● Sokoloff, Juan, Baoling Zhou, Lingyi Zhang, and Srikanth Namuduri. 2018. “Digital Traces of Gentrification.” New York University Center for Urban Science and Progress. Accessed December 2018. https://srikanth261.wixsite.com/cusp. |

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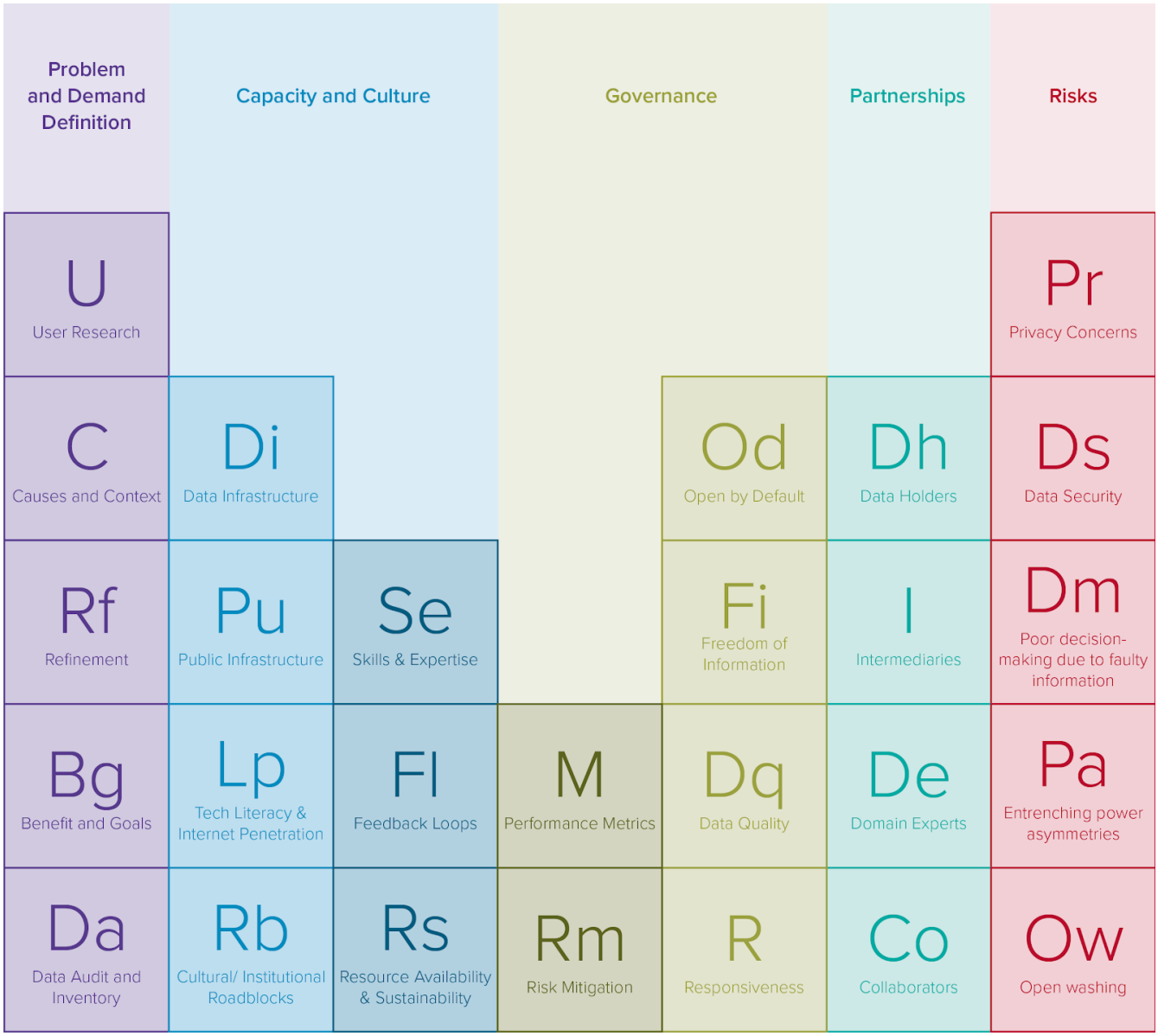
|---|---|---|
| | | **Sources *(continued)*** • NYU Furman Center. 2016. “Report Analyzes New York City’s Gentrifying Neighborhoods, Finds Dramatic Demographic Shifts.” May 9, 2016. http://furmancenter.org/news/press-release/report-analyzes-new-york-citys-gentrifying-neighborhoods-finds-dramatic-dem. |

### Enabling Conditions and Risks and Challenges

**Figure 1:** Open Data Periodic Table, The GovLab




In previous sections of this paper, we detailed factors that might enable or complicate different circular data use cases. To gain a greater grasp of the enabling conditions, risks, and challenges that could impact the success or failure of a circular data initiative, we have sought to apply and translate The GovLab's Periodic Table of Open Data for this context.

Developed as part of an in-depth exploration of open data's global impact, The Periodic Table of Open Data focuses on enablers, challenges, and risks related to uses of open government data. Through the research and analysis that informed this paper, we have found that the majority of the factors identified

as instrumental for open government data use cases also play important roles in the circular data context. Indeed, the five central categories included in the Periodic Table still hold relevance: Problem and Demand Definition, Capacity and Culture, Partnerships, Risks, Governance.[3] Within those broader categories, however, we have made a number of additions and revisions in line with circular data's value propositions and barriers to success. Below we outline the elements comprising this new Periodic Table of Circular Data.

### Problem and Demand Definition

A clear, detailed understanding of the problem to be addressed by circular data can help to ensure that efforts are targeted and optimized. Clearly defining the problem can also aid in the development of metrics of success and a strategy for monitoring progress against a well-defined baseline. Without such a monitoring strategy, making assessments of impact, evidence-driven iteration, and the demonstration of return on investment are likely to remain elusive. Specific elements include:

- **User Research**: The up-front identification, mapping, and understanding of relevant constituencies and a similar examination of their needs
- **Causes and Context**: Understanding both why a specific problem is occurring and the environment in which it exists
- **Refinement**: Distilling the problem by seeking to understand, for instance, why it exists in its current form, what contributing factors could be at play, what potential knock-on effects of addressing the problem might be, and why the problem has not yet been solved by some other interested party
- **Benefits and Goals**: Defining the project's end goal and potential benefits to build an audience, measure progress, and expand successfully over time
- **Data Audit and Inventory**: Once the problem and value proposition are in place, practitioners can determine whether their cache of circular data is able to address the problem and whether there might be other potentially useful and relevant data sources they can use

### Capacity and Culture

The lack of available resources, insufficient human capital, and immature technological capabilities can create major barriers to achieving meaningful impact with circular data. These challenges are particularly salient on the demand side of circular data—whether the intended user base resides in the public, civil, or other parts of the private sector. Specific elements include:

- **Data Infrastructure**: Ensuring the relevant actors have access to the hardware and software platforms to make data consistently accessible and machine-readable in a timely manner
- **Cultural/ Institutional Roadblocks**: Overcoming an institutional culture that remains skeptical or coping with the absence of well-trained individuals capable of recognizing and acting on the potential of data

[3] For examples of how the Periodic Table might be used to better understand open government data projects in developing economies, please see Verhulst and Young (2017).

- **Skills and Expertise**: Ensuring actors on the demand side—including City Government agencies—possess the readiness, skills, and expertise to effectively use the data
- **Feedback Loops**: Ensuring users and beneficiaries can provide input to demand-side practitioners
- **Resource Availability and Sustainability**: Guaranteeing the project has funding and/or a well-defined business model that can allow the work to continue long-term, including by ensuring pricing models are commensurate with the budgetary expectations and constraints of the intended user base

### Governance

A diversity of governing decisions affect the use and impact of circular data. Issues of governance exist at both the ecosystem level—especially related to standards and policies of data sharing, as well as challenges and constraints arising from government procurement mechanisms—and on the demand side, with questions of risk mitigation and impact assessment leading the way. Specific elements include:

- **Performance Metrics**: Developing and monitoring metrics of impact to inform management and iteration
- **Risk Mitigation**: Ensuring a clear, up-front strategy exists for addressing the risks presented by sensitive information
- **Data Stewardship**: Defining processes and empowering individuals on the supply side of circular data to assess and act upon opportunities for collaboration
- **Data Quality**: Having processes to ensure data is accurate, complete, timely, and uncorrupted to avoid skewing analysis
- **Responsiveness**: Ensuring demand-side actors can commit to act upon released data

### Partnerships

In essence, circular data initiatives are experiments in new forms of data-driven partnerships. Whether creating touchpoints with citizens through partnerships with civil society, informing the public through media partnerships, or filling important data gaps through partnerships with other companies and organizations, circular data suppliers and users often improve outcomes through collaboration. Specific elements include:

- **Data Holders**: Engaging with other data holders who might be useful partners
- **Intermediaries**: Working with individuals possessing relevant skills to determine whether available data-driven outputs reach a community of users and the intended impact is reached
- **Domain Experts**: Tapping into the knowledge of sector-specific stakeholders who can help optimize and target data efforts based on a true understanding of needs, opportunities, and barriers to success
- **Collaborators**: Collaborating with like-minded organizations, institutions, or individuals to address the identified problem

Risks

The generation, sharing, and use of circular data are not without risks. An up-front mapping and consideration of risks across the data lifecycle—Collecting, Processing, Sharing, Analyzing, Using—can allow practitioners to design programs from the outset in a way that is well-positioned to overcome or mitigate those risks. The risks outlined here, however, should not be considered arguments against experimentation with the use of circular data. Rather, they are reasons for taking a more fine-grained approach that pays close attention to the empirical evidence, sifting out what works and what does not, and identifying conditions for scaling and replication. Specific elements include:

- **Privacy Concerns**: Ensuring the data cannot unexpectedly disclose information of a specific person or be combined with openly available data to otherwise identify them
- **Data Security**: Building the cybersecurity mechanisms to protect sensitive information from sophisticated hackers and other intrusions
- **Poor Decision-making Due to Faulty Information**: Recognizing that insights generated from data are only as good as the quality of the underlying data and that incomplete, out-of-data, or otherwise faulty data can lead to disastrous decisions
- **Entrenching Power Asymmetries**: Acknowledging the privileges and authority inherent in societies and the capacity for data to reinforce those power imbalances
- **Innovation Theater**: Acknowledging that some actors may refuse or fail to act on the insights generated but participate in a project only to increase their reputation or bolster their attempts to achieve some other goal

## Next Steps and Recommendations

As the previous canvases illustrate, circular data presents many possible opportunities for economic development. However, these opportunities require businesses to work intelligently, to test and probe ways to make these suggested approaches real and sustainable. The previous research and GovLab's experiences in this field suggest a few steps and recommendations that can help businesses be successful in using circular data:

- Focus on **City Data Collaboratives**, not just Data Supply. Data does not exist in isolation. The success of circular data projects will depend on collaboration among various stakeholders, as well as collaboration with data scientists and topic or sector experts ("bilinguals"). During the problem definition and initial design phase, practitioners and funders should explore the types of collaborations that could increase uptake and impact. Such partnerships could, for example, take place with other data providers (perhaps from different sectors), like-minded national or local organizations, as well as established intermediaries such as journalists or industry groups.[4]

[4] For real-world data collaborative examples, see "Data Collaboratives Explorer" (2018).

- Explore new and innovative **Business Models** for leveraging circular data. Previous research suggests six potential models: Assets Sales; Usage Fees; Leasing; Licensing; Subscription Fees; Brokerage Fees; and Advertising Fees. The cost structure of these models, meanwhile, can either be value-driven, emphasizing innovative and novel solutions over cost, or cost-driven, offering solutions that are cheap compared to competitors.[5]
- Consider the creation of **Internal and External Intermediaries**. To increase the value of circular data, a wide range of internal and external intermediaries can potentially add value, credibility, and rigor to data collaboratives. Data collaboratives often may need to leverage the skills, expertise, and capacity of intermediaries in academia, topic-relevant community-based organizations, and data science organizations, among other actors. Strategies for identifying potentially valuable intermediaries within the New York City context, and for maximizing the added value of different third parties engaged as part of the collaboration could aid New Lab companies in achieving their objectives for maximizing the public value of the data their companies hold.[6]
- **Develop Safe Sandboxes** for Innovation and Experimentation (vs. Procurement). Circular data projects need to be mindful of some of the important risks associated with even the most successful projects. Notably, these risks include threats to individual privacy (for example, through insufficiently anonymized data) and security. At the same time, existing policy and procurement frameworks are often prohibitive toward innovating with new data sets and data science approaches. Safe Sandboxes provide a framework within which innovators can test data ideas and models on a “live” problem, under relevant supervision, and without fear of enforcement actions, in case it is determined that the model does not comply with existing regulations. This “safe space” is usually subject to certain restrictions, typically focused on ensuring the protection of consumers, including a limited amount of time for testing. Such an approach can ensure that circular data experimentation does not automate, operationalize, and legitimize bad decision-making.
- **Focus on Resource Scarcity** (among both the Demand and Supply). Circular data projects can often be initiated with minimal resources and goodwill among all parties, but require funding and additional resources to sustain themselves and scale. It is important to recognize that access to these resources at the outset is not necessarily a sign that data projects are destined for long-term success. A longer term, yet flexible, business and operational model or strategy is a key driver of sustainability, and should be developed in the early stages of the design process.
- **Define Metrics and Gather Evidence**. To be systematic, define and measure what success looks like. Although there are some early, often muted signals pointing to the impacts of circular data for economic development, the field is still largely built on a limited understanding of how circular data creates demonstrable positive outcomes.[7] To move to a more evidence-based understanding of circular data in New York City, we need to distill a theory of change, define metrics, and design an analytical framework informed by the current practice, not to further

[5] Informed by the framework developed by Mcloughlin, Puvvala, Maccani, and Donnellan (2019) in their study of the EU H2020 project OrganiCity and the 40 experimental cases it funded.
[6] Data intermediaries are recognized as important in any data project for connecting data providers with their end users. See Schalkwyk, Caňares, Chattapadhyay, and Andrason (2015).
[7] Evaluating new practices of problem solving is often difficult but is essential to determining which interventions are effective. See Barnett, Dembo, and Verhulst (2013).

entrench faith in the positive narrative surrounding data, but to create a flexible analytical framework that can inform future research and impact assessment. This can inform the identification of a number of premises—in the form of apparent enabling conditions and disabling factors for circular data initiatives—but these premises need further study (and scrutiny) by the research field to determine whether or not they hold water in practice. If circular data is to reach its significant potential for spurring economic development, we need to move beyond ideology to create a systematic understanding and evidence base regarding what its impacts have been to date and how positive impacts can be enabled.

## References:

Barnett, Aleise, David Dembo, and Stefaan Verhulst. 2013. “Toward Metrics for Re(Imagining) Governance: The Promise and Challenge of Evaluating Innovations in How We Govern.” SSRN Scholarly Paper ID 2563794. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=2563794.

Berends, John, Wendy Carrara, and Cosmina Radu. 2017. “Analytical Report 9: The Economic Benefits of Open Data.” European Open Data Portal. https://www.europeandataportal.eu/sites/default/files/analytical_report_n9_economic_benefits_of_open_data.pdf.

Bliss, Laura. 2018. “Brooklyn Is Booming. So Why Is It Shrinking?” CityLab, March 23, 2018. https://www.citylab.com/equity/2018/03/brooklyn-is-booming-so-why-is-it-shrinking/556280/.

Campanile, Carl. 2017. “These People Are the Biggest Losers in Brooklyn’s Gentrification.” *New York Post* (blog), November 6, 2017. https://nypost.com/2017/11/06/hipsters-are-driving-low-income-hispanics-out-of-brooklyn/.

Corrêa d'Almeida, André and Caroline McHeffey. 2019. “The Circular City Program: The Case Study.” In *The Circular City Research Journal*, edited by André Corrêa d'Almeida, 17-44. New York: New Lab, 2019.

Crudele, John. 2017. “The Challenges of Driving a Yellow Cab in the Age of Uber.” *New York Post*, September 19, 2017. https://nypost.com/2017/09/18/the-challenges-of-driving-a-taxi-in-the-age-of-uber/.

“Data Collaboratives Explorer.” 2018. Data Collaboratives. http://localhost:4000/explorer.html.

Day One Staff. 2018. “Amazon Selects New York City and Northern Virginia for New Headquarters.” *US Day One* blog, November 13, 2018. https://blog.aboutamazon.com/company-news/amazon-selects-new-york-city-and-northern-virginia-for-new-headquarters.

Forman, Adam. 2014. “Caution Ahead: Overdue Investments for New York’s Aging Infrastructure.” Center for an Urban Future, March 2014. https://nycfuture.org/research/caution-ahead.

Forman, Adam. 2017. “The New Geography of Jobs: A Blueprint for Strengthening NYC Neighborhoods.” Office of the New York City Comptroller. April 25, 2017. https://comptroller.nyc.gov/reports/the-new-geography-of-jobs-a-blueprint-for-strengthening-nyc-neighborhoods/.

Glen, Alicia, James Patchett, Gregg Bishop, Marisa Lago, David Ehrenberg, Julie Menin, Barbara Chang, et al. 2017. “New York Works: Creating Good Jobs.” Office of the Mayor of New York. https://newyorkworks.cityofnewyork.us/.

Kheirbek, Iyad, Katherine Wheeler, Sarah Walters, Grant Pezeshki, and Daniel Kass. 2011. “Air Pollution and the Health of New Yorkers: The Impact of Fine Particles and Ozone.” New York City Department of Health and Mental Hygiene. https://www1.nyc.gov/assets/doh/downloads/pdf/eode/eode-air-quality-impact.pdf.

Mcloughlin, Shane, Abhinay Puvvala, Giovanni Maccani, and Brian Donnellan. 2019. "A Framework for understanding & classifying Urban Data Business Models." In *Proceedings of the 52nd Hawaii International Conference on System Sciences*. January 2019.

New York City Information Technology and Telecommunications. 2018. “City of New York Releases Annual Open Data Report, Featuring New York City Data at Work.” https://www1.nyc.gov/site/doitt/about/press-releases/annual-open-data-report-2018.page.

New York Mayor’s Office of Recovery and Resiliency. 2018. “Climate Resiliency Design Guidelines.” https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v2-0.pdf.

New York State Department of Labor. 2019. “State’s Private Sector Jobs Reach All-Time High in December 2018.” January 17, 2019. https://labor.ny.gov/stats/pressreleases/pruistat.shtm.

Office of the New York City Comptroller. 2018. “The Gap Is Still Growing: New York City’s Continuing Housing Affordability Challenge.” https://comptroller.nyc.gov/reports/the-gap-is-still-growing-new-york-citys-continuing-housing-affordability-challenge/.

Office of the New York State Comptroller. 2019. “An Economic Snapshot of Brooklyn.” Report 3 (2019). https://osc.state.ny.us/osdc/rpt3-2019.pdf.

Schalkwyk, François van, Michael Caňares, Sumandro Chattapadhyay, and Alexander Andrason. 2015. “Open Data Intermediaries: Their Crucial Role.” World Wide Web Foundation. August 18, 2015. https://webfoundation.org/2015/08/open-data-intermediaries-their-crucial-role/.

Small, Andrew. 2017. “Tracking the Incredible Gentrification of New York City.” CityLab, April 28, 2017. https://www.citylab.com/work/2017/04/the-gentrification-of-gotham/524694/.

Verhulst, Stefaan, Andrew Young, and Prianka Srinivasan. 2018. “Introduction.” *Data Collaboratives*. 2018. http://datacollaboratives.org/introduction.html.

Verhulst, Stefaan, and Andrew Young. 2017. “Open Data in Developing Economies: Toward Building an Evidence Base on What Works and How.” New York City, New York: The GovLab. http://odimpact.org/files/odimpact-developing-economies.pdf.

The World Bank. 2019. “Starting an Open Data Initiative.” January 24, 2019. http://opendatatoolkit.worldbank.org/en/starting.html.

# Circular Data for a Circular City: Value Propositions for Mobility

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## Summary[8]

Mobility is at the core of our daily urban lives. It represents the most active sector of the urban technology space, based on venture capital investment. Cities and local governments more and more try to make their decisions based on data. Sadly, mobility data is often missing or at least very fragmented. There have been, to date, few successful efforts to share such data, and even fewer to conduct research and answer the two following questions: (a) what is the value of data sharing? and (b) what are the conditions to foster impactful data sharing?

The Circular City program is a data-sharing experiment initiated by New Lab in Downtown Brooklyn, New York to answer these two questions. New Lab partnered with three local start-ups and had them share (or, rather, circulate) their data with city agencies.

In this paper, we show how the data contributed by the three start-ups participating in the program (CARMERA, Numina, and Citiesense) can help New York City agencies when making key decisions related to mobility issues. We present a framework to categorize the data provided (supply side), the data needs from the city (demand side), and show how they match. We also try to quantify the value of sharing and provide some key lessons for both start-ups and cities to foster such data sharing.

## Definitions

We start with a few definitions that will be used all across this paper.

### Smart City

A smart sustainable city is an innovative city that uses information and communication technologies and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, and environmental aspects (International Telecommunications Union 2015).

### The Circular City

New Lab's The Circular City program is a first-of-its-kind experiment to test whether collaboration between the public and private sector can be intentionally designed to build trust, reciprocity, and a shared vision of public and private good capable of making cities smarter and defining a more resilient, sustainable future for cities (Corrêa d'Almeida 2019).

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Circular Data

Circular data refers to the collection, production, and exchange of data and business insights between a series of collaborators, around a shared set of inquiries (Corrêa d'Almeida 2019). In some scenarios, data may be produced by start-ups and of high value to the city; in other cases, data may be produced by the city and of potential value to the public, start-ups, or enterprise companies.

Mobility

As the space consisting of the following areas (McKinsey Global Institute 2018):

- Real-time public transit information
- Digital public transit payment
- Autonomous vehicles
- Predictive maintenance of transportation infrastructure
- Intelligent traffic signals
- Congestion pricing
- Demand-based micro transit
- Smart parking
- E-hailing (private and pooled)
- Car sharing
- Bike sharing
- Integrated multimodal information
- Real-time road navigation
- Parcel load pooling
- Smart parcel lockers

## 1. Introduction

Every year, Brooklyn Bridge Park holds Photoville, an annual photography festival hosted in a modular venue made from repurposed shipping containers. The 2017 edition hosted 92,000 attendees, 600 artists, 75 photography exhibitions. Tickets for the event are managed through the Eventbrite platform. Visitors may choose to use a combination of public transport (bus, subway, Citi Bike) and on-demand transport (Uber, Lyft, taxis) to get from and to the venue. For security and safety reasons, the New York City Police Department (NYPD), the New York City Fire Department (FDNY), and paramedic services may have to allocate extra resources and personnel[9] for the event. To the best of our knowledge, data is not currently shared among actors taking part in this event: the organizer, the ticketing company, the transportation company, city agencies. If ticketing data could be shared ahead of time and/or in real time, (a) ridesharing companies could dispatch more drivers to the event location, (b) Citi Bike could temporarily expand to nearby locations or rebalance existing ones, and (c) NYC safety agencies could

[9] Unplanned and last-minute allocation of city resources usually cost extra because the dispatched personnel need to be paid overtime.

allocate the proper resources for the event. The meaningful use of such shared data would improve mobility and use of city resources.

Mobility, "*the first powerful wave of the smart city movement*" (McKinsey Global Institute 2018, 82) is at the core of our daily urban lives. Mobility represents the most active sector of the urban technology space, with 61% out of an estimated $76.6B of venture capital investment (Florida 2018). Cities and local governments more and more try to make their decisions—including mobility decisions—based on data. But mobility data is often missing or at least very fragmented. There have been, to date, few successful efforts[10] on either the public, private, or academic sides to share such data, and even fewer to conduct research about it and answer questions such as: (a) what is the value of data sharing? and (b) what are the conditions to foster impactful data sharing? New Lab's The Circular City program is—to the best of our knowledge—the first attempt at answering these questions.

New Lab's The Circular City program is an experiment to "test whether collaboration between the public and private sector can be intentionally designed to build trust, reciprocity, and a shared vision of public and private good capable of making cities smarter and defining a more resilient, sustainable future for cities" (Corrêa d'Almeida 2019, 12). With this goal in mind, New Lab partnered with three local start-ups that produce data: CARMERA, Numina, and Citiesense. For the details of this partnership and more information about each start-up, we point our reader to the Introduction to this *Research Journal*.

This paper will focus on mobility data and mobility use cases "circulated" as part of The Circular City program. We will try to provide answers to the question of the value of data sharing and the conditions required to foster impactful data sharing. We will take a business-to-government (B2G) point of view with start-ups as data suppliers to the City.

The rest of this paper is organized as follows. In Section 2, we explain what makes data valuable and how to think about it. Sections 3 and 4 present the supply-and-demand sides of the circular data, by looking at the data sets provided by the start-ups and the data needs expressed by the City. Section 5 brings the two together by showing how supply and demand intersect. We also try to quantify the value of the shared data and look at risks and costs. In Section 6, we share some takeaways applicable to both start-ups and cities willing to enter a circular collaboration.

## 2. How to think about data

No one needs to be convinced of the value of data. In 2006, Michael Palmer quoted British data scientist Clive Humby—"Data is the new oil!"—then went on, "It's valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc. to create a valuable entity that drives profitable activity; so must data be broken down, analyzed for it to have value" (Palmer 2006).

In this section, we briefly review what makes data valuable and how to think about data. We will reuse some terminology introduced in Smichowski (2018).

[10] Shared Streets and Coleridge Initiative are two recent examples.

Data is valuable for what it permits us to do. Chignard and Benyayer (2015) identify four verbs—"describe," "explain," "predict," and "prescribe"—for what data allows us to do. Verhulst, Zahuranec, and Young (2019) define the following five vectors: "situational analysis," "cause-and-effect analysis," "prediction," "impact and value assessment," and "ecosystem support." Later in this paper, we will focus on "planning," "impact measurement," "prioritization," and "enforcement" in the context of New York City.

Data is also valuable based on some intrinsic properties of the information it contains. Smichowski (2018) clusters these properties into three top-level categories: size, quality, and scope. The first category (size) is pretty evident. "The larger a data set, the more valuable it becomes." This is particularly true in the context of machine-learning algorithms that require lots of data and where usually more data beats clever algorithms (Halevy, Norvig, and Pereira 2009). The second category (quality) usually encompasses a wide range of dimensions such as accuracy, freshness, etc. A good overview of data quality can be found in Taleb, Serhani, and Dssouli (2018). The third category (scope) refers to the recombining property of the data, or how easily the data can be linked to other data sets. In the U.S., census data is a great example of a data set with a very broad scope. Smichowski (2018) mentions Google Search data as the holy grail of data sets because it can be linked and is relevant to almost every single domain.

In the context of this paper, we will use the following data taxonomy when describing the kind of data the various stakeholders are dealing with:

- **Raw Data:** also known as primary data, is data directly collected from a source. Raw data has not been subjected to processing, "cleaning" by researchers to remove outliers, obvious instrument reading errors or data entry errors, or any analysis.
- **Processed Data:** data that has been processed from raw data where processing may include cleaning, aggregation, conversion to a different format, etc.
- **Combined Data:** data that is the result of bringing together multiple data sources, e.g., pedestrian count and weather data.
- **Data Sold to Customers:** data packaged as a data set the customer can download or packaged as a service the customer can query via an API. In both cases (data set and API), the data is contingent on a fee and the customer also expects a service level agreement in terms of quality, freshness, etc.
- **Data Given In-Kind:** the same as Data Sold to Customer with no contractual obligations in terms of quality, freshness, etc. The data is often given "as is."
- **Usage Data:** data about how users consume the data. In the context of web data and Google, data is information about the Web (pages, the content of pages including text, images, etc.) while usage data is the popularity of these pages based on queries.

Our focus in this paper is on mobility. The following table provides a list of various kinds of data that can be collected through ground-level imagery, a restriction we imposed based on the mode of collection used by our Circular City partners.

**Table 1:** A Taxonomy of Mobility Data

| | |
|---|---|
| **Where** | • street<br>• curb<br>• sidewalk<br>• street façade (to a limited extent the façade) |
| **What** | • city infrastructure, e.g., roads, bridges<br>• city static assets, e.g., bench, trash can, street sign<br>• city mobile assets, e.g., city fleet<br>• people<br>• people's assets, e.g., car, bike, wheelchair, stroller<br>• business<br>• business's assets, e.g., truck, terrace areas<br>• plants, e.g., trees<br>• animals, e.g., dogs, pigeons<br>• special conditions, e.g., road closure, construction, flooding |
| **Metrics** | • count<br>• aggregate<br>• velocity<br>• heat maps<br>• trajectories |

Before we close this section, Chignard and Benyayer (2015) provide us with the perfect segue when they state that “data has value only if it circulates.”

## 3. Circular city data: the supply side

In this section, we describe the data sets provided by the three start-ups who are part of The Circular City program and their potential value.

### Circular city data provided by the start-up partners

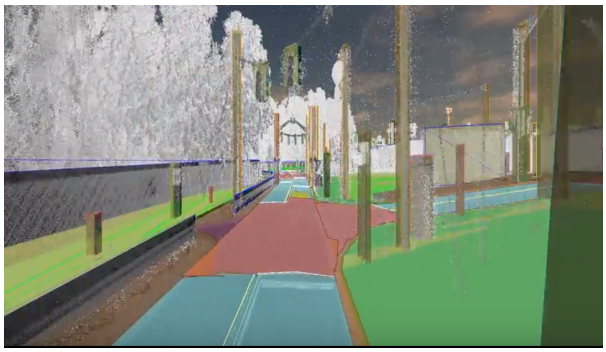
As mentioned previously in this paper, our focus is on data produced by the start-ups, not data produced by the City.

*CARMERA data*

CARMERA is a street intelligence platform for autonomous mobility. It offers three products:

- CARMERA Autonomous Map is an HD mapping suite that provides real-time navigation-critical data for autonomous vehicles, allowing them to know where they are, confirm what they're seeing, and know where to go next.
- CARMERA Site Intelligence provides spatial data and street analytics, including block-level pedestrian analytics, and historical trend data.
- CARMERA Fleet Monitoring is a visual telematics service CARMERA provides professional high-coverage fleets, like delivery trucks, in exchange for the placement of powerful and inexpensive roof-mounted camera-only sensors on fleet vehicles to collect real-time update data independent of CARMERA's autonomous vehicle customers.

**Figure 1:** CARMERA products

| | |
|---|---|
|  |  |
| Pedestrian Density Report from Site Intelligence | HD Map |

A CARMERA map is generated in two steps: the base (semantic) layer of the map is generated from LiDAR and RGB scans and then continuously updated from camera-only sensors that detect changes.

*Numina data*

Numina "measures what, where, when, and how things move in streets and open space, to help city planners, mobility companies, and other stakeholders design better systems for people, bicycles, wheelchairs, strollers, and more" (Numina n.d.).

The Numina device is mounted/strapped to light poles. Its camera operates in the visible spectrum and analyses images at 4-5 frames per second.  All processing is done locally on the device (edge computing as opposed to cloud computing). Counts and trajectories are aggregated and pushed to the cloud every 15 minutes. The set of entities recognized by Numina currently includes car, bus, trucks, bikes, and pedestrians, and keeps growing as new AI and machine-learning capabilities are introduced.

**Figure 2:** Numina appliance (left), imagery (center), and count (right)

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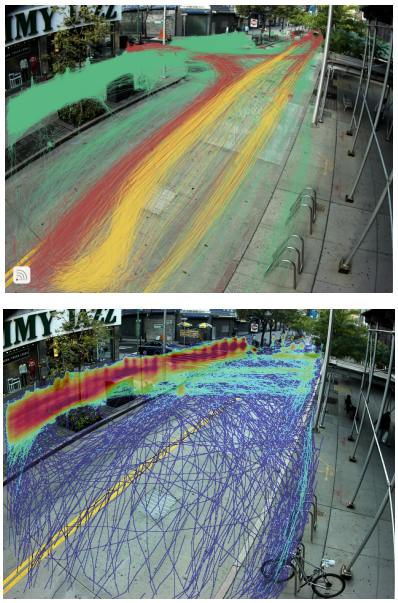
<td>  </td>
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<tr><td>A Numina device</td><td>What Numina sees</td><td>Data sent to the cloud</td></tr>
</table>

*Citiesense data*

Unlike the other two start-ups, Citiesense does not collect or sell data itself. Rather, it sells access to a knowledge-management platform that enables place-based community organizations and their members to create a valuable knowledge base for data about their neighborhood. The platform achieves this goal by centralizing the tools used to manage community assets, such as data about local businesses, real estate development, streets, and parks.

Sidewalk Labs (a subsidiary of Google Alphabet and a leader in the urban tech space) often talks about "reimagining cities from the internet up." The analogy between the Web and the urban space is a very good way of understanding how these three start-ups fit together and why they were hand-picked by New Lab for The Circular City program. CARMERA's fleet partners crawl the city to gather information the same way web spiders crawl the Web. Numina publishes data feeds for targeted locations the same way a sitemap.xml file provides detailed information about the latest changes on a website. And all of this information can be combined via Citiesense's dashboards like search engines would do for web content.

## Circular city data taxonomy

We make the distinction between various types of data, as data gets "refined" (to borrow the "data is the new oil" analogy).

**Raw data** is the data collected on the ground.

- For CARMERA, the raw data consists of imagery collected by the roof-mounted cameras on the fleet partner vehicles and autonomous vehicle customers, as well as LiDAR data collected by CARMERA-managed or customer vehicles and 3rd party mobile mapping systems.
- For Numina, the raw data consists of *object tracks*, where each track consists of a unique identifier, an object category (pedestrian, bicyclist, car), and a sequence of time-stamped positions.

**Processed data** is a derived product of the raw data, sometimes combined with third-party data.

- For CARMERA, processed data consists of extracted features or relative scores from video footage and the LiDAR measurement to reconstruct an accurate 3-D map of the urban environment.
- For Numina, processed data consists of features extracted and aggregated from tracks, mainly counts by category, location, and time bucket.
- For Citiesense, the main source of data is third-party data, and the value-add of Citiesense is to combine these various data sources.

**Third-party data** is data acquired from third-party vendors or customers with a goal to be combined with existing data.

**Published data** is the data packaged to be sold to customers or given away.

- For CARMERA, the data are sold to customers in the form of real-time HD maps for autonomous vehicles (CARMERA Autonomous Map) and 3-D scene reconstruction and street-level analytics (CARMERA Site Intelligence).
- For Numina, the data sold to customers is detailed counts (geo-located time series) per type of feature.
- For Citiesense, the data "sold" to customers is the data combined across multiple data sources. Citiesense is more about offering a service than offering data itself.

**Usage data** is the data (or metadata) about how customers are using the published data.

- To the best of our knowledge, there is no direct way for CARMERA and Numina to capture this information.
- For Citiesense, this is a natural by-product of the service it offers. By putting some simple analytics on its dashboards and various other services, it can capture the kind of data its customers care about, e.g., top queries, top areas, etc.

The data lifecycle is summarized in Table 2.

**Table 2:** Data Taxonomy

| | **Raw data** | **Processed data** | **Third-party data** | **Published data** | **Usage data** |
|---|---|---|---|---|---|
| **CARMERA** | Street imagery LiDAR Point Clouds | Reconstructed 3-D imagery Counts | Customer image data | Autonomous Map Site Intelligence | N/A |
| **Numina** | Object tracks | Counts | N/A | Counts | N/A |
| **Citiesense** | N/A | N/A | Yes | N/A | Yes |

## Data challenges

To describe the data challenges, we will reuse the steps identified by the data taxonomy (collection, processing/integration, and publishing) and map them across four categories inspired by size, quality, and scope presented in Section 2. Given the data sets provided and our focus on mobility, we look at *scale* (instead of size); we look at quality as described by *freshness* and *accuracy*; and we look at *privacy,* which can be understood as anti- or negative scope since it aims at preventing further recombination of data.

One key property of both CARMERA and Numina data sets is that they are geocoded (space) and timestamped (time) which gives them a very rich scope.

For CARMERA, a big challenge is to deploy its cameras on the ground. This is why it is partnering with existing fleets, for which it built a Fleet Monitoring service. A big challenge for CARMERA is, of course, technical: detecting changes in street-level conditions and then updating the vectors in its semantic basemaps with the freshness, speed, and accuracy required for autonomous vehicles. In terms of privacy, information such as faces and license plates are blurred as soon as possible and LiDAR imagery does not permit the identification of people. Captured imagery is retrieved at either the end of each day or processed in the device and over the cloud when the “event” is detected that may cause an autonomous vehicle disengagement, like construction.

**Table 3:** Data Challenges for CARMERA

| Challenges / Data lifecycle | Scale | Freshness | Accuracy | Privacy |
|---|---|---|---|---|
| **Data collection** | Global scale, collected by CARMERA, its customers and 3rd parties | Fleet partners and customers | < 10-20 cm | PII blurred for camera-only sensor N/A for LiDAR |
| **Data processing** | In the cloud | Some change detection in device | Algorithm-based | PII blurred as early as possible |
| **Data publishing** | N/A | Based on collection and processing. Real-time for traffic-impacting events; daily for lower priority changes | Algorithm-based | |

For Numina, data collection is limited by the number of devices deployed and their fixed location. Because of their fixed nature, Numina devices capture information 24 hours a day, 7 days a week, 365 days a year. A salient feature of the Numina solution is the fact that computation is done on the edge: features are extracted from ground imagery on the device and only count aggregates are being transmitted to the cloud. Data exported from the device is anonymous by design and can, therefore, be published safely.

**Table 4:** Data Challenges for Numina

| Challenges / Data lifecycle | Scale | Freshness | Accuracy | Privacy |
|---|---|---|---|---|
| **Data collection** | Limited by device deployment | Always fresh | Algorithm-based | Computation done on the edge |
| **Data processing** | In the cloud | Always fresh | Algorithm-based | Computation done on the edge |
| **Data publishing** | N/A | Always fresh | Algorithm-based | N/A |

For Citiesense, the main challenge is to get access to relevant data feeds, integrate them, and visualize them.

**Table 5:** Data Challenges for Citiesense

| Challenges / Data lifecycle | Scale | Freshness | Accuracy | Privacy |
|---|---|---|---|---|
| **Data collection** | Based on data acquisition from third parties | Based on data acquisition from third parties | Based on data acquisition from third parties and algorithms used for data integration | N/A |
| **Data processing** | In the cloud | Always fresh | Algorithm-based | N/A |
| **Data publishing** | Via Citiesense cloud-based product | Based on data acquisition and Citiesense data processing | Algorithm-based | N/A |

Before we move on to the demand side (from the City), we want to remind the reader of the three key priorities identified by Verhulst, Zahuranec, and Young (2019) for any business willing to create value from data: (1) increasing revenue and market share, (2) optimizing existing processes, and (3) fostering innovation.

## 4. The mobility use case: the demand side

To better understand the needs of the city in terms of mobility, we conducted interviews with the New York City Department of Transportation (DOT), which—unlike many other such departments in smaller metros—designs and executes most of its projects. The key role of the DOT is better described below:

> Over 5,000 employees of the New York City Department of Transportation oversee one of the most complex urban transportation networks in the world. DOT's staff manage an annual operating budget of $900 million and a five-year $10.1 billion capital program, along with 6,000 miles of streets and highways, 12,000 miles of sidewalk, and 794 bridges and tunnels, including the iconic East River bridges. DOT's staff also installs and maintains over one million street signs, 12,700 signalized intersections, over 315,000 street lights, and over 200 million linear feet of markings. (New York City Department of Transportation, n.d.)

## Four purposes for mobility data

In speaking with the DOT, it was determined that mobility data is currently being used for four distinct purposes: (a) planning, (b) impact measurement, (c) prioritization, and (d) enforcement. Not surprisingly, and as mentioned in Section 2, they overlap with the four verbs from Chignard and Benyayer (2015) and the five vectors from Verhulst, Zahuranec, and Young (2019).

### *Planning*

Planning is the obvious one. Mobility data can inform a lane reduction because of low traffic, an intersection redesign (because of pedestrian risks), or a traffic signal replacement with all-way stops. Data can also inform policies such as speed reduction, parking time limits, etc. More examples can be found in Speck (2018).

### *Impact measurement*

Impact measurement is critical for initiatives like Vision Zero[11] where safety measures can have an impact on traffic speed, e.g., lane reduction, speed humps and speed bumps, etc. Construction and road closures also have an important impact on foot traffic and, therefore, on businesses.

### *Prioritization*

Prioritization was heavily used for the design of Vision Zero projects through the crowdsourcing of dangerous intersections and dangerous behaviors (Corrêa d'Almeida 2018).

### *Enforcement*

Enforcement is important for safety but can also be a source of revenue for the city, e.g., fines and parking tickets. Mobility-related fines in New York City amounted to almost $700 million in revenue for 2016 (New York City Office of the Comptroller 2017a).

All of this is done in the spirit of the OneNYC Vision, a blueprint for the future of New York City, built on prior long-term plans with a focus on growth, sustainability, resiliency, and equity, and anchored in a regional perspective (OneNYC, n.d.).

## Data needs from the City

The current mobility-data needs span four different categories.

### *Finer-grain traffic info for bikes, ridesharing, and freight*

[11] Vision Zero is a program created by New York City Mayor Bill de Blasio in 2014. Its purpose is to eliminate all traffic deaths and serious injuries on New York City streets by 2024 (Wikipedia, n.d.).

New York City and the DOT in particular care a lot about how streets are being used and by whom. Given the recent Citi Bike expansion, with a $100 millon investment from Lyft, (Citi Bike NYC, n.d.), the City is very eager to understand better where bikes are circulating. Citi Bike data only provides start and end points for a given trip.

The City is also very interested in the growing popularity of e-bikes, which were recently added to the Citi Bike fleet. But not all e-bikes operate the same and the City wants to regulate them accordingly (Surico 2018). Pedal assist (you pedal and the bike helps you) and non-pedal assists are treated differently by the City. From a data collection point of view, it means that, for bike-journey data to be useful for the City, it would need to go beyond recognizing "a bike" and be able to identify the type of bike being used.

The City also has a strong and vested interest in Transport Network Companies (TNC) like yellow cabs, Uber, Lyft, etc. Even though the City has, in theory, access to TNC data via the Taxi and Limo Commission (TLC), they would like to get a precise count of taxi-vs-Uber-vs-Lyft-vs-Via-vs-other. The City could decide to cap the number of TNC vehicles in the streets (Fitzsimmons 2018a) or follow the example of Barcelona and impose even more drastic restrictions like booking a ride 15 minutes, at minimum, in advance (Lomas 2019).

Finally, the City also has a strong focus on freight, as large trucks are a key factor in traffic jams. Getting a sense of where trucks go (lawfully or not) would help them provide better guidance to truck companies in terms of routes to avoid. This would also have some clear benefits for air quality, noise pollution, and climate change.

### *Foot traffic*

Mobility has a huge impact on the local economy, as illustrated in Speck (2018). When the City makes changes to its urban fabric—street, curb, sidewalk—this may have some consequences for the local economy. Therefore, the City is very eager to measure such impacts by gathering foot traffic information. More details on the economic development angle, we refer the reader to Verhulst, Zahuranec, and Young (2019).

### *Curb info*

Curbs are the essential connector between transportation and pedestrians. The City is eager to understand how curbs are being used and abused, for instance for parking, double parking, and construction.

Curb info can also be very relevant to public transportation, as exemplified by the recent bus challenge issued by The Transit Tech Lab[12], in which innovators are encouraged to find solutions for bus lanes being obstructed by illegally parked vehicles.

[12] The Transit Tech Lab is an accelerator program for start-ups, launched by The Transit Innovation Partnership, a public-private initiative between the Metropolitan Transportation Authority and the Partnership for New York City.

*Façade info*

The City is also very interested in façade data—the exterior side of a building, usually the front—popularized by services like Google Street View. The Department of Finance licensed street imagery from a Dutch company called Cyclomedia for the purpose of property tax assessment (New York City Office of the Comptroller 2017b). Other use cases for such data include identification of dangerous structures, construction progress, etc.

## 5. Value proposition for circular city data: supply meets demand?

In Section 3, we gave an overview of the supply side, by looking at the kind of data currently produced by the participants of the Circular City program. In section 4, we listed some needs of New York City in terms of data related to mobility. In this section, we are putting the two together to see how supply and demand match. We look at what already exists and what could be done. We also try to quantify the value of sharing and its risks and costs.

### Matching supply and demand

We summarize the matching of demand with supply in the table below.

The first thing to note is that circular city data already covers well the important use cases identified by the City. However, the main limitation is the scale of the data sets. For CARMERA, data collection is limited by the coverage of the fleet (both in terms of space and time). For Numina, data collection is limited by the number of deployed devices.

Regarding the fine-grain traffic data where the City would like to distinguish between ride-hailing/sharing companies or between types of bikes, the good news is that the data should be a training set away. Both CARMERA and Numina have already deployed infrastructures where entities are recognized using advanced machine-learning algorithms. To make them distinguish between a yellow cab, a Lyft, or an Uber, one only needs a good enough training data set. To make them distinguishable between a pedal-assist and non-pedal-assist e-bike, one only needs a good enough training data set. As we will suggest in the next section, these training data sets are what the City could create or have mobility providers create as part of being allowed to operate in the City.

**Table 6:** Demand Meets Supply

| Demand \ Supplier | CARMERA | Numina | Citiesense |
|---|---|---|---|
| **Fine-grain traffic**<br>- Cars<br>- Trucks<br>- TNC by type<br>- Bikes<br>- Bikes by type | <br>Yes<br>Yes<br>??<br>Yes<br>?? | <br>Yes<br>Yes<br>??<br>Yes<br>?? | N/A |
| **Foot traffic** | Yes, normalized; | Yes, observed; limited to Numina deployments | N/A |
| **Curb info** | Yes; | Yes; limited to Numina deployments | N/A |
| **Façade info** | Yes if in the sightline of fleet or via Lidar | No | |
| **Dashboards** | N/A | N/A | Yes, assuming data is available |

## Price, value, and cost of circular city data

Before we start, let's remind ourselves of the difference between cost, price, and value.

- The cost of a product or service is the amount spent to produce or deliver it.
- The price is the financial reward for providing the product or delivering the service.
- The value is what the customer believes the product or service is worth to them.

Despite lots of research on the topic, there is very little we can say quantitatively about the value of data sharing. A recent experiment in Denmark in which they established a data-sharing platform for the City of Copenhagen remains very fuzzy in its final report (Copenhagen and Denmark 2016): "The most sought-after dataset includes information on how people move around in different places, and times in an area" (3).

Verhulst, Zahuranec, and Young (2019) use some proxies for monetary value, such as $2.8 billion for delayed truck deliveries in the New York area or $100 billion over 5 years for traffic congestion in the New York metro. These numbers really consider the value of the solved problem rather than the value of the data that could contribute to solving the problem.

But what if we desperately needed to put a price tag on some data, e.g., to convince the City to acquire a data set (either through money or in-kind) or to convince a start-up CEO that sharing the data makes sense from a business point of view. In the following, we will try to price three real-life examples.

In the context of the Vision Zero initiative, the City promised to spend $400 million over six years (Meyer 2017). For such projects, impact evaluation is critical because of all the moving parts and ripple effects we alluded to in Section 4. Best practices for impact evaluation as reported in “Research & Evaluation Spending Benchmarks” (ProofPilot 2017) range from 10% to 15% for government, and 1.5% to 7.5% for the non-profit sector. The Hewlett Foundation, a pioneer in this space, has set its goals at 2% (Arbreton, Trivedi, and Twersky, n.d.).

**Table 7:** Impact Evaluation Investment for Vision Zero

| **Evaluation as % of program spending** | **Amount per year** |
|---|---|
| 15% | $10 million |
| 10% | $6.6 million |
| 2% | $1.3 million |

This means that having New York City spend between $1.3 million and $10 million per year to measure the impact of Vision Zero would be aligned with industry best practices. Such funds could be used, for instance, to purchase a data set from CARMERA for traffic speed and density or a data set from Numina for bike traffic in areas where a recent Vision Zero intervention was conducted.

We previously mentioned the special interest for façade information by the City. Looking at open data provided by the City Comptroller, we can find the price that was paid for this specific data set. The record shows that the City is paying Cyclomedia $8 million for a 6-year contract to provide "streetscape imagery" (New York City Office of the Comptroller 2019). Façade data is not the main focus of CARMERA data collection. But if it were, the value of such a data set could be approximated by the figure above.

Our last example comes from California, where the City of Los Angeles was forced into a $1.4 billion settlement to invest, over the next 30 fiscal years, in city sidewalks compliant with Americans with Disabilities Act (ADA) regulations (Iwasaki 2017). Curb information collected by CARMERA or sidewalk trajectories collected by Numina could offer early detection of such problems in the future. Dashboards provided by Citiesense could help with inventory and tracking of non-compliant sidewalks.

### Risks and costs

In the context of open data, a large body of work has been done that looks at what triggers and stymies the sharing of data. The "calculus for open data" (Sahuguet and Sangokoya 2015) is an attempt at summarizing the various forces at work. In the rest of this section, we will revisit the calculus in the context of circular data.

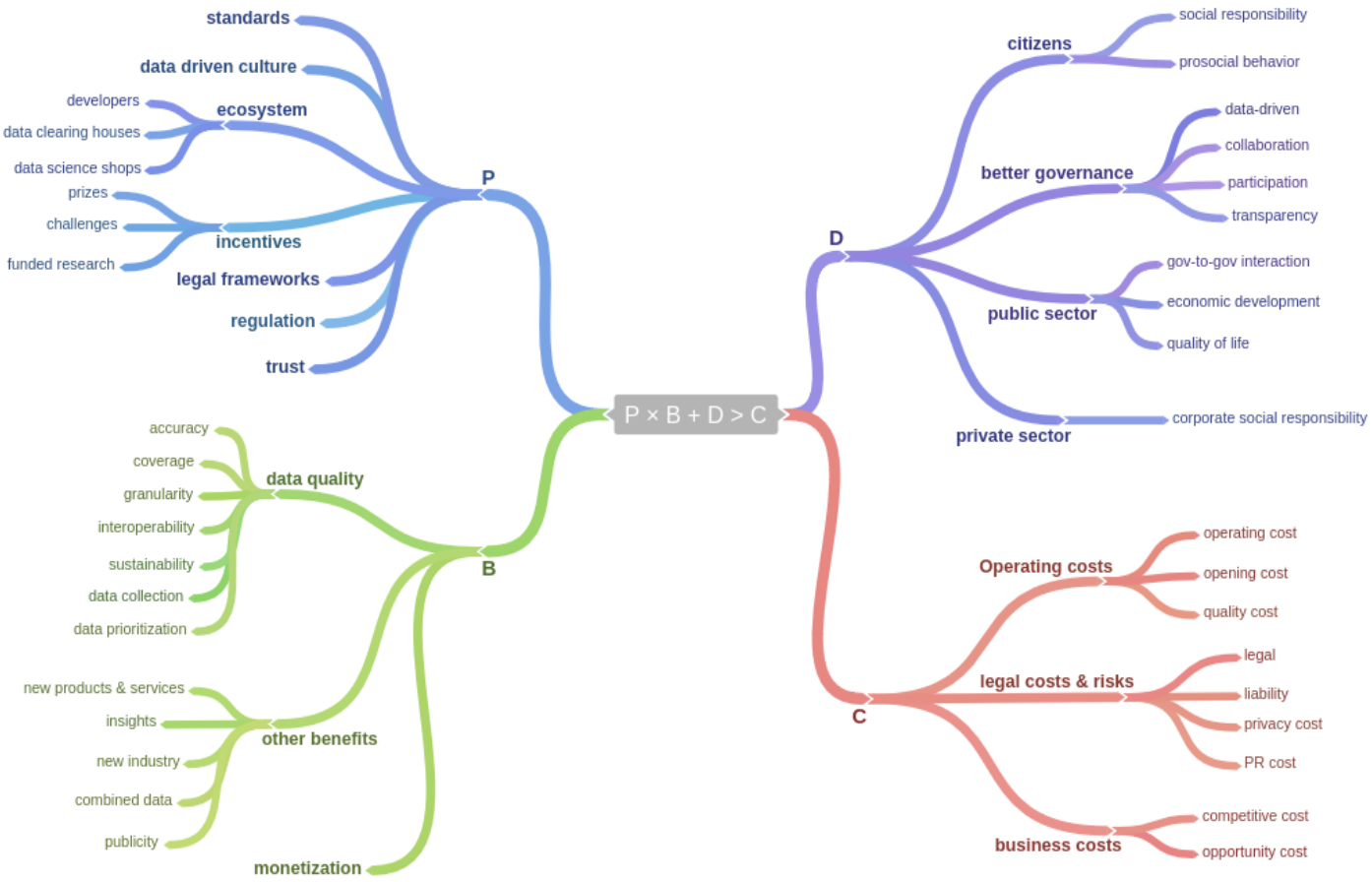
The calculus relies on this simple formula: P × B + D > C, where—when adapted to circular data:

- P is the probability that circulating the data will have some effect
- B is the individual benefit of circulating the data
- D is the global or ecosystem impact
- C is the cost

Any increase in P, B, or D and a decrease in C will make the outcome of circulating the data better.

We will not revisit all the factors that influence each variable, but we mention the ones that we think are more relevant in the context of The Circular City program.

**Figure 3:** A "Calculus" for Open Data (Sahuguet and Sangokoya 2015)



Opportunity cost is critical, especially for start-ups who have limited resources and funding. For CARMERA, the data sets of interest to the City are not the ones they sell to their customers. For Citiesense, a bespoke dashboard might not be relevant to other customers.

Quality cost is also critical. Circular data sharing is not a one-time event but a continuous exchange. This means that processes need to be put in place to make sure that fresher data is supplied in a format that is compatible with older versions.

Competitive cost is often a deal breaker when the data you share can be used by the competition. As far as we know, competitive cost is not applicable to the current participants of the program. However, for a start-up like JUMP (provider of e-bikes and e-scooters, a New Lab member, and recently acquired by Uber), sharing scooter data could help its competition identify the best routes.

We conclude this section with the two following ironic observations that show that such matchmaking between supply and demand is more an art than a science.

From a data collection point of view (for the base map based in LiDAR data), the ideal conditions for CARMERA would be empty roads, empty curbs, and no pedestrians on the sidewalk. This would lead to a perfect unobstructed measurement of the street. This "noise" (street traffic, curb occupancy, foot traffic) is what the City cares about the most.

CARMERA generates a lot of data about this “noise,” but they currently do not have the technical bandwidth to package this data into data sets they can distribute to non-commercial customers.

## 6. Lessons Learned

In this section, we provide a list of takeaways (a) for start-ups willing to operate in and cooperate with cities and (b) for cities looking to leverage their local start-up ecosystem.
Start-ups and cities need to work together. This is even truer in the mobility space. After a first round of implementation during which cities embraced a wait-and-see attitude, they are now fighting back. Some ride-hailing/sharing companies have been banned from cities (BBC News 2018), quotas have been proposed for the number of vehicles in the streets (Fitzsimmons 2018b), and scooter fees broached (Marshall 2018), etc. Barcelona is even considering a delay of 15 minutes before a pick-up and no display of real-time geolocation of vehicles for hire in the ride-hailing apps prior to booking (Lomas 2019).

### Takeaways for start-ups

Operating and doing business in a city is hard, with many obscure regulations and the hurdle of procurement.

*Find the right partners*

CARMERA is working with fleet partners. Through a win-win arrangement, CARMERA provides a visual telematics and safety monitoring service to fleet managers in exchange for image data about streets, independent of its core commercial customers. It purposefully built such a product/service in order to convince partners to put the CARMERA camera on their dashboard.

Through this program, New Lab brought Downtown Brooklyn Partnership to the table so that Numina could work with them and deploy their technology in a more rapid way and with a clear connection to local quality-of-life issues. The Downtown Brooklyn Partnership (DBP), the business improvement district (BID) for Downtown Brooklyn, manages streetlight poles, infrastructure for which Numina required access in order to deploy their product. This is much easier than navigating the opaque process set into motion when pursuing official deployment via the New York City Department of Transportation. Similarly, Citiesense is working first with various BIDs to showcase its technology and refine its product offering before approaching the City directly.

For the three start-ups, New Lab has been the perfect partner because of its unique role, mission, and positioning in the New York City ecosystem. Through The Circular City program, New Lab has convened a set of collaborators and created the conditions for such partnerships to flourish. They have found opportunities to collaborate, e.g., Numina data is a good static complement to CARMERA mobile data collection. Citiesense's dashboards are an excellent delivery mechanism for the data CARMERA and Numina want to contribute/donate to the City. Leveraging such dashboards allow them to showcase the value of data without having to spend engineering capacity on building stuff that they won't sell anyway.

*Make your value proposition clear, including second-order effects*

CARMERA's main customer is not the City; it is autonomous vehicle (AV) companies in need of high-definition (HD) maps to deploy. But fostering the development of AVs in the City will most likely generate a lot of value. CARMERA Fleet Monitoring could be extremely relevant to City agencies that recently installed CANCeiver[13] inside vehicles of their fleet. CARMERA Site Intelligence is also extremely relevant for planning and impact measurement. Therefore, since CARMERA is not looking to enter a financial customer-client relationship with the City, collaboration is based on the long-term need for this company to invest in working effectively with cities and understanding where their product can most deliver positive impact in exchange for the access they need to operate at scale.

The value proposition for Numina is straightforward: real-time insights from streets via its deploy-anywhere sensor solution. The challenge is that it is often perceived as a vitamin (nice-to-have) rather than a pain-killer (must-have). As more city agencies move towards data-driven decision making, a Numina deployment could become required as a way of measuring the impact of any urban innovation, e.g., bike lane, lane reduction, terrasse permitting. This is the case we started to build in Section 5.2. Similarly, the value proposition for Citiesense is pretty clear, as all this information needs to be integrated and displayed in a user-friendly, visually appealing, and actionable way.

[13] CANceiver collects data for vehicle status, location, and driver behavior (E.J. Ward, n.d.).

### *Share actionable data sets*

In an ideal scenario, all relevant data sets should be shared with the City. But this is not always possible. Start-ups should identify data sets relevant to cities that are not proprietary or directly linked to their business and make them available. But giving away data sets is usually not enough; a city usually lacks imagination or expertise. Data must be provided *in context*, in the form of a report (e.g., CARMERA Site Intelligence, see Figure 1) or rely on a third party or a partner like Citiesense to package and visualize the data in an accessible and actionable manner.

### *Be aware of opportunities & limitations*

During the course of this research project, (a) we learned that NYC traffic cameras don't have a high enough resolution to offer Automated License Plate Recognition (ALPR), (b) NYCx (out of the Mayor's Office of the Chief Technology Officer) has issued a few challenges to which all three start-ups have something to contribute, and (c) the Transit Innovation Partnership has issued a bus challenge to which CARMERA technology is directly applicable. City assets can be leveraged. City data, directly used by the City or acquired from a third party (e.g., Cyclomedia), can be leveraged, too.

### *Earn your data karma points*

As encouraged in Sahuguet and Sangokoya (2015), opening your data may bring a lot of value. Beyond the obvious value to the City, it might be a good way to attract talent who are motivated by social good. Given the hyper-competitive nature of the NYC job market, this is not something to discard.

## Takeaways for cities

Cities cannot be as nimble as start-ups. Balancing innovation, finances, and quality of life for their residents has become even harder in our era of permissionless innovation where the mantra is to "ask for forgiveness rather than permission."

### *Understand the challenges of urban data*

Urban data remains a poorly defined term. But this is what cities have to deal with. A framing like the one presented in Section 2 should be useful.

Cities have to be transparent regarding the privacy of their residents, in terms of what data is collected and for what purpose. The European Union General Data Protection Regulation (GDPR) framework is a good example to follow. Cities have to stay away from exclusive agreements that would prevent access to data or make it prohibitively expensive. Cities should also be mindful of "ghost urban data," urban data that disappears from their sight because it is now being captured by third-party companies. In cities that do not regulate the operation of ride-hailing/sharing companies, a passenger taking a ride does not appear in the city mobility data set (like a ghost). Fortunately, this is not the case in New York City (Marshall 2019).

*Understand how AI works and invest accordingly*

At the core of the CARMERA and Numina products and services we have some powerful computer-vision AI that have been trained using rich data sets. Today these algorithms can recognize cars, trucks, strollers, wheelchairs, etc. Tomorrow, they can recognize whatever one trains them to recognize.

Cities need to understand this new fundamental model where algorithms are not handcrafted by humans anymore but are fed data (Villani 2018) . They need to understand what can be done and what is hard. They need to understand the value of such training sets and encourage sharing. But, in some cases, they may have to be the gatekeepers of such data sets in order to foster competition.

*Leverage your assets*

In Detter and Fölster (2017), the authors remind us of the numerous assets (social, human, and economic wealth) that cities already own but is out of sight—or “hidden." In our context of The Circular City program, we will focus on data and data-related assets.
Cities should make their data available via an open-data portal. Bulk data sharing is much cheaper in the long run than responding to individual FOIA[14] requests. When doing so, they should prioritize "good basic data for everyone" as described in (Ministry of Finance, Government of Denmark 2012), and keep in mind that data monetization is compatible with an open-data mandate.[15]

Cities should leverage their mobile assets. New York City operates large fleets of vehicles, including the police (NYPD), the fire department (FDNY), and garbage trucks (Department of Sanitation). These fleets are prime candidates to collect data. CARMERA is already partnering with private fleets. They could also work with city fleets.

Cities should also leverage their static assets, e.g., streetlights, bus stops, benches, etc Numina is working with the Downtown Brooklyn Partnership, which operates the streetlights in Downtown Brooklyn.

*Flex your muscles*

We already alluded to this at the beginning of this section. Cities have a lot of power through the policies they design and enforce. Cities can and should make sure that providers operating in the mobility space and using urban resources share their data.

[14] The Freedom of Information Act (FOIA) is a United States federal law that grants the public access to information possessed by government agencies. Upon written request, U.S. government agencies are required to release information unless it falls under one of nine exemptions listed in the Act (Rouse n.d.).
[15] A good analogy is stock market data: financiers are eager to pay for real-time stocks, while the rest of us are happy to get stock prices delayed by 15 minutes for free.

They should put regulation in place to have a say in what data gets collected and for what usage (à la GDPR, for urban data). Cities should also mandate partners to use open standards to avoid vendor lock-in for data.

*You can start today*

Cities can start today to leverage their start-up ecosystems. Since the inception of The Circular City program, various City initiatives have kicked-off ambitious collaborations with the private sector including, NYCx moonshots, NYC BigApps, and Transit Innovation Partnership challenges. One key element of these challenges is the willingness to share problems and challenges to be solved and provide access to data and domain expertise.

**Conclusion**

Mobility is at the inner core of our urban lives. What used to be the exclusive preserve of cities and governments is now being disrupted by the private sector and its permissionless innovations. Data-driven decision-making applied to mobility requires solid mobility data. Unfortunately, such data is often fragmented and hard or pricey to assemble. What if such data could be shared or, rather, circulated between stakeholders?

In this paper, we have presented some initial research on The Circular City program initiated by New Lab in Downtown Brooklyn, NY. The premise of The Circular City program is that "collaboration between the public and private sector can be intentionally designed to build trust, reciprocity, and a shared vision of public and private good capable of making cities smarter and defining a more resilient, sustainable future for cities." In this paper, we tried to answer the following two questions, in the context of mobility data: (a) what is the value of data sharing? and (b) what are the conditions to foster impactful data sharing?

To answer (a), we first considered the supply side in the form of the mobility data provided by CARMERA, Numina, and Citiesense, before we looked at demand side in the form of mobility use cases that matter to the City. We identified some existing "matches" and also suggested some good candidate matches that should require minimal extra work on either side. But quantifying the value of data sharing remains elusive.

To answer (b), we referenced and adapted some prior work done on open data (Sahuguet and Sangokoya 2015) to identify some levers that can foster sharing. We also listed a set of lessons learned for both sides (start-ups and cities) to make such sharing possible.

There is still a lot of work to be done. First, data is only the tip of the iceberg. Data becomes relevant when coupled with an algorithm making decisions. The circular sharing should extend beyond data to also include algorithms and models. Second, to make such sharing scale, we need to go beyond a "benevolent convener," that encourages participants to circulate data sets. This role was expertly played by New Lab, but it has its limits. A "marketplace," like the one deployed for the city of Copenhagen (Copenhagen and Denmark 2016), seems to be the natural evolution for The Circular City, with features

like catalogue, dictionary, search, publishing, integration, and payment. Third, new business models and policies need to be explored or invented, to align the incentives of the various participants, as presented in Smichowski (2018).

Despite some obvious limitations, with only three start-ups and a deployment limited to Downtown Brooklyn, New Lab's The Circular City program is an exciting and courageous experiment that tries to redefine data sharing and its value. As an infrastructure for collective learning, it provides a virtuous cycle of public-private collaboration whereby new ideas, new challenges, and new partners are introduced to accelerate innovation and rapidly develop, test, evaluate, and scale new technology in order to address urban challenges, push the smart-cities market forward, and positively impact the quality of life in cities. Some early lessons from The Circular City program will hopefully be learned by cities and start-ups worldwide to solve society's pressing urban challenges.

## Appendix A: SWOTs

Below we summarize some of the lessons in the form of a SWOT analysis for each participant of The Circular City Program in the context of the program.

**Table 1:** SWOT for CARMERA

| **Strengths** | **Weaknesses** |
|---|---|
| Technology<br>Partnerships<br>Coverage<br>Cost | Technical bandwidth to provide the right data set to non-commercial customers |
| **Opportunities** | **Threats** |
| Leverage city fleets, e.g., garbage trucks<br>Richer sets of entities recognized<br>More data given away to cities | Policy change disrupting fleet partnerships or AVs<br>AV companies building maps in-house |

**Table 2:** SWOT for Citiesense

| **Strengths** | **Weaknesses** |
|---|---|
| Technology | Does not own the data<br>Lack of competitive advantage<br>Hard to penetrate market |
| **Opportunities** | **Threats** |
| Need for a platform to integrate data<br>More AI | |

**Table 3:** SWOT for Numina

| **Strengths** | **Weaknesses** |
|---|---|
| Technology<br>Hardware<br>Privacy-friendly | Limited number of deployed devices<br>Cost of device<br>Access to city real estate to deploy devices<br>Privacy-by-design limiting monetization opportunities |
| **Opportunities** | **Threats** |
| Richer set of entities recognized<br>Extend beyond imagery, e.g., radio, sensory, etc.<br>Policy requirement to measure impact for all city projects<br>Partnership with companies like CARMERA in need of greater coverage<br>Deployed physical equipment is a beach for future services based on sensors, QR codes, etc. | Alternate ways of data collection, e.g., crowdsourcing, CCTV cameras<br>Vandalism |

**Table 4:** SWOT for New York City

| **Strengths** | **Weaknesses** |
|---|---|
| New York City, where new tech comes to audition<br>Trove of data<br>Active players, e.g., NYCx, NYC EDC, FCNY, etc<br>Top talent | Late in the game<br>Few pockets of tech savviness across agencies<br>Procurement as a barrier to innovation<br>Data fragmentation |
| **Opportunities** | **Threats** |
| Policy power to force data sharing<br>Monetization | Ghost data when data not shared with the City |

## References

Arbreton, Amy, Prithi Trivedi, and Fay Twersky. 2018. “The Value of our Evaluations: Assessing Spending and Quality.” Hewlett Foundation, February 2018. https://www.hewlett.org/wp-content/uploads/2018/02/Evaluation-Quality-and-Spending-Analysis-2018.pdf.

BBC News. 2018. “Uber granted short-term licence to operate in London.” June 26, 2018. https://www.bbc.com/news/business-44612837.

Chignard, Simon, and Louis-David Benyayer. 2015. *Datanomics. Les nouveaux business models des données*. Limoges, France: FYP editions.

Citi Bike NYC. n.d. “Citi Bike is Going to Dramatically Expand!” Accessed November 29, 2018. https://www.citibikenyc.com/blog/citi-bike-is-going-to-dramatically-expand.

The City of New York. n.d. “OneNYC: The Plan for a Strong and Just City.” Accessed December 3, 2018. http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf.

Coleridge Institute. n.d. “Home page.” Accessed February 14, 2019. http://coleridgeinitiative.org/.

Copenhagen, Municipality of, and Capital Region of Denmark. 2016. “City Data Exchange – Lessons Learned From A Public/Private Data Collaboration.” https://cphsolutionslab.dk/content/2-what-we-do/3-data-platforms/3-city-data-exchange/1-learnings-from-the-city-data-exchange-project/city-data-exchange-cde-lessons-learned-from-a-public-private-data-collaboration.pdf?1527149474.

Corrêa d’Almeida, André, ed. 2018. *Smarter New York City: How City Agencies Innovate*. New York: Columbia University Press.

Corrêa d'Almeida, André. 2019. “Introduction to The Circular City Research Program.” In *The Circular City Research Journal*, edited by André Corrêa d'Almeida, 7-14. New York: New Lab, 2019.

Detter, Dag, and Stefan Fölster. 2017. *The Public Wealth of Cities: How to Unlock Hidden Assets to Boost Growth and Prosperity.* Washington, D.C.: Brookings Institution Press.

E.J. Ward. n.d. “CANceivers.” Accessed February 14, 2019. http://ejward.com/solutions/canceivers/.

Fitzsimmons, Emma G. 2018a. “New York Could Become First Major U.S. City to Cap Uber and Similar Vehicles.” *New York Times*, July 26, 2018. https://www.nytimes.com/2018/07/26/nyregion/new-york-city-council-uber-limit.html.

Fitzsimmons, Emma G. 2018b. “Uber Hit With Cap as New York City Takes Lead in Crackdown.” *New York Times*, August 8, 2018. https://www.nytimes.com/2018/08/08/nyregion/uber-vote-city-council-cap.html.

Florida, Richard. 2018. “The Rise of ‘Urban Tech.’” CityLab, July 10, 2018. https://www.citylab.com/life/2018/07/the-rise-of-urban-tech/564653/.

Halevy, A., P. Norvig, and F. Pereira. 2009. “The Unreasonable Effectiveness of Data.” *IEEE Intelligent Systems* 24 (2): 8–12.

International Telecommunications Union. 2015. “Focus Group on Smart Sustainable Cities.” https://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx.

Iwasaki, Naomi. 2017. “It’s time to Stop Trippin’: Fixing the City of LA’s Sidewalks.” Investing in Place, October 18, 2017. https://investinginplace.org/2017/10/18/its-time-to-stop-trippin-fixing-the-city-of-las-sidewalks/.

Lomas, Natasha. 2019. “Rules to rein in ride-hailing apps coming to Barcelona.” *Techcrunch*, January 29, 2019. https://techcrunch.com/2019/01/29/rules-to-rein-in-ride-hailing-apps-coming-to-barcelona.

Marshall, Aarian. 2018. “Milking Scooters for Cash Helps Cities Build for the Future.” *Wired.com*, November 6, 2018. https://www.wired.com/story/scooters-cities-fees-mobility/.

Marshall, Aarian. 2019. “NYC Now Knows More than Ever About Your Uber and Lyft Trips.” *Wired.com*, January 31, 2019. https://www.wired.com/story/nyc-uber-lyft-ride-hail-data/.

McKinsey Global Institute. 2018. “Smart Cities: Digital Solutions For A More Livable Future.” McKinsey Global Institute, June 2018. https://www.mckinsey.com/~/media/mckinsey/industries/capital%20projects%20and%20infrastructure/our%20insights/smart%20cities%20digital%20solutions%20for%20a%20more%20livable%20future/mgi-smart-cities-full-report.ashx.

Meyer, David. 2017. “Here’s How de Blasio Will Spend $400 Million on Street Safety Improvements.” *Streetsblog NYC*, January 25, 2017. https://nyc.streetsblog.org/2017/01/25/heres-how-de-blasio-will-spend-400-million-on-street-safety-improvements/.

Ministry of Finance, Government of Denmark. 2012. “Good Basic Data for Everyone.” https://uk.fm.dk/publications/2012/good-basic-data-for-everyone/.

New York City Department of Transportation. n.d. “About DOT.” Accessed February 14, 2019. http://www.nyc.gov/html/dot/html/about/about.shtml

New York City Office of the Comptroller. 2017a. “New York City Fine Revenues Update.” May 3, 2017. https://comptroller.nyc.gov/reports/new-york-city-fine-revenues-update.

New York City Office of the Comptroller. 2017b. “Checkbook NYC.” https://www.checkbooknyc.com/contracts_landing/status/R/year/118/yeartype/B/agency/218?expandBottomContURL=/panel_html/contract_transactions/agid/3643080/status/R/doctype/CT1

New York City Office of the Comptroller. 2019. “Checkbook NYC.” https://www.checkbooknyc.com/smart_search?search_term=cyclomedia.

Numina. n.d. “Home page.” Accessed November 30, 2018. http://www.numina.co/.

Palmer, Michael. 2006. “Data is the New Oil.” November 3, 2006. https://ana.blogs.com/maestros/2006/11/data_is_the_new.html.

ProofPilot. 2017. “Research & Evaluation Spending Benchmarks.” March 1, 2017. https://proofpilot.com/research-evaluation-spending-benchmarks/.

Rouse, Margaret. n.d. “Freedom of Information Act.” https://whatis.techtarget.com/definition/Freedom-of-Information-Act.

Sahuguet, Arnaud, and David Sangokoya. 2015. “A ‘calculus’ for Open Data.” *Medium*, February 9, 2015. https://medium.com/@sahuguet/p-b-d-c-1218ee894400.

Shared Streets. n.d. “Home page.” Accessed February 14, 2019. https://sharedstreets.io/.

Smichowski, Bruno Carballa. 2018. “The Value of Data: An Analysis of Closed-Urban-Data-Based and Open-Data-Based Business Models.” https://hal.archives-ouvertes.fr/hal-01736484/document.

Speck, Jeff. 2018. *Walkable City Rules: 101 Steps to Making Better Places*. Washington, D.C.: Island Press.

Surico, John. 2018. “New York City Makes (Some) Space for E-Bikes.” CityLab, April 6, 2018. https://www.citylab.com/transportation/2018/04/new-york-city-makes-space-for-e-bikes/557396/.

Taleb, Ikbal, Mohamed Adel Serhani, and Rachida Dssouli. 2018. “Big Data Quality: A Survey.” In *Big Data Congress 2018*. https://doi.org/10.1109/BigDataCongress.2018.00029.

Verhulst, Stefaan, Andrew Zahuranec, and Andrew Young. 2019. “Circular Data for a Circular City: Value Propositions for Economic Development.” In *The Circular City Research Journal*, edited by André Corrêa d'Almeida, 45-95. New York: New Lab, 2019.

Villani, Cédric. 2018. “For A Meaningful Artificial Intelligence.” https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf.

Wikipedia. n.d. “Vision Zero (New York City).” Accessed February 14, 2019. https://en.wikipedia.org/wiki/Vision_Zero_(New_York_City).

# Circular Data for a Circular City: Value Propositions for Resilience and Sustainability

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## Summary

Downtown Brooklyn's vibrant economic community and start-up businesses may be generating ancillary data that could feed into the need for data on resiliency and sustainability at city agencies and economic development advocacy organizations such as business improvement districts (BIDs). The presence of street litter and trash in commercial areas depresses economic activity, washes out into the sewer system which contaminates waterways and marine habitat, and encourages the spread of rats and disease. New York city agencies overseeing waste management, water quality, and public health may also have street-level data that may benefit local start-ups' commercial objectives and capabilities. This paper analyzes the methods, platforms and data of three Downtown Brooklyn tech start-ups, two of which use cameras and analytics to spot conditions, while one develops a platform that integrates data from many sources at the street level. The paper reviews past literature and data collection methodologies to ascertain whether the start-ups' methods could provide more reliable, efficient, and comprehensive data than is currently feasible. Past efforts to collect such data have been labor-intensive and relied on modeling. Improved street-level data has the potential to affect agency efforts to control street litter, which could lead to less floatable debris and trash flowing into local waterways, better rat control, and an improved streetscape benefitting area businesses and residents. The new methodologies may also be scalable outside of Downtown Brooklyn.

## Introduction

This paper will examine the possible benefits of circular data among data companies and New York City agencies within downtown Brooklyn related to resilience and sustainability. In particular, the paper will focus on how tech start-up information could improve the already vibrant and rapidly growing commercial and residential neighborhood through better data on street and sidewalk waste and litter. In other words, the research will look at whether tech start-ups, academia, and urban-tech professionals can organize, analyze, distribute, and implement data systems which create value so as to improve resiliency in the study area in Downtown Brooklyn, NY. After this initial stage, the aim would be to see whether such a model could be applied more broadly outside the study area in New York City, and potentially other dense urban commercial and residential areas.

Throughout New York City, Business Improvement Districts (BIDs) are non-profit membership organizations that play an important role in economic development and livability of neighborhood-scale commercial areas. They provide key services to members, including marketing, government liaison, and supplemental trash and litter removal. The Downtown Brooklyn Partnership (DBP) manages three BIDs in the area, and promotes Downtown Brooklyn as a destination for business, culture, education, and retail, building on civic community values. The area within DBP's jurisdiction is the study area for The Circular City program.

This paper of The Circular City program seeks to determine whether the technologies and services offered by the three tech participants have the potential to provide better data, in a more efficient way, than is currently available to BIDs and city agencies on key aspects of resiliency and sustainability, including environment, health, and economic development. As an initial test, we will focus on trash and

street litter data, as well as waste-truck traffic in the study area. In addition, this preliminary inquiry explores whether data collected by New York City agencies may benefit the three tech participants. Trash and litter were selected because their presence is associated with public health issues such as rats, as well as depressing economic activity and street life in a neighborhood. As such, they are of concern to community residents and businesses, as well as to agencies that manage health, sustainability, resiliency, and economic development. Altogether, the aim is to assess whether value can be created by a circular system of data collection and dissemination, and what conditions need to be put in place to make the circular system work.

## Problem statement and definitions

Over the last 10 years, the onset of climate-related extreme events has increased interest and initiatives around the subject of resiliency in urban settings. For example, the 100 Resilient Cities initiative, spearheaded by the Rockefeller Foundation, works with cities to develop their capacity to “survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience” (100 Resilient Cities, n.d.). In New York City, this attention to resilience became especially focused after the destruction wrought by Hurricane Sandy in 2012, with 44 casualties and $19 billion in damages and lost economic activity (OneNYC 2015, 216). The impacts to neighborhoods in Brooklyn and Staten Island in particular are felt to this day.

Within urban settings, the terms “resiliency” and “sustainability” are often used together and at times interchangeably, and they are closely related in much of the literature. There is no one accepted definition for both, and there are likely dozens of definitions. “Resiliency” is most often associated with the ability to recover from one-time shocks to urban systems, or the ability to surmount chronic stresses (“bounce back”). Another variation states that resiliency means an urban system that comes back even stronger than it had been before the shock or stress (“bounce forward”) (Romero-Lankao et al. 2016). Resiliency in New York City’s policymaking often has a local focus, down to the neighborhood level, that is rooted in the city prioritizing community bonds and looking at the ground-level impacts of climate change, including urban heat island effects, emergency response, and environmental justice (OneNYC 2015).

Traditionally, sustainability in urban settings was defined as limited to environmental categories such as water, air, and climate. The definition of “sustainability” has more recently been broadened. The one that is often currently used in urban settings is the one adopted by the United Nations’ Brundtland Commission: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Our Common Future 1987). It incorporates environmental, economic, and social aims.

Within an urban setting, resiliency and sustainability fit together. They share goals that look forward to the future, as well as equity both among generations and across socioeconomic classes and geographical areas. Urban areas require that sustainability be kept on track, that it be resilient, and that recovery or surmounting and thriving from shocks and stresses be achieved in order to meet environmental, economic, and social goals.

In 2015, New York City announced its new long-term sustainability plan—OneNYC. OneNYC proposed four overarching visions of resiliency, growth, and equity along with the original PlaNYC vision of environmental sustainability. It adopted a definition of resiliency that was broader than emergency response, setting a goal that "Every city neighborhood will be safer by strengthening community, social, and economic resiliency" (OneNYC 2015, 215). The plan applied its components at the neighborhood level when it came to sustainability and resiliency, with a similar focus for economic development. The plan also took an interdisciplinary and interagency approach, so that its initiatives ideally met objectives outlined in more than one of the four visions. When it came to the resiliency vision, a new neighborhood goal explicitly set forth the importance of enhancing community bonds. For economic development, supporting small businesses was another key aim. It is in that vein that this paper looks at the potential value of data on waste and litter at the local level, in this case within a thriving commercial district.

## Downtown Brooklyn: a test bed for innovation grounded in local business needs

Downtown Brooklyn is one of the fastest-growing business districts in New York City. Between 2010 and 2015 it added over 15,000 new jobs, boasting a 26 percent increase in that time period. As of 2016, it had 2,000 businesses per square mile, 45,000 residents, and $3.9 billion in annual retail and dining sales. Most of the fast growth is driven by the tech, information, entertainment, and arts sectors. Its growth rates are higher than the average for all of New York City (Downtown Brooklyn Partnership 2018).

The Downtown Brooklyn Partnership (DBP) is a not-for-profit local development corporation that serves as the main champion for the neighborhood as a world-class center for business, culture, residential, and other sectors. It manages three business improvement districts (BIDs): MetroTech, Court-Livingston-Schermerhorn, and the Fulton Mall Improvement Association, which is New York City's first BID (Downtown Brooklyn Partnership, n.d.). Among its activities are recruiting and retaining businesses, marketing, supplementing city services, and promoting a sense of place and enhanced community bonds.

BIDs are commercial, geographic areas for which local member businesses and other stakeholders fund and direct promotional, maintenance, and improvement activities. They also serve as a liaison between the members and local government officials. Sanitation makes up a substantial portion of the budgets of most city BIDs. In FY2017, for Court-Livingston-Schermerhorn it was 45 percent, Fulton Mall 25 percent, and MetroTech about 21 percent. By percentage, the BIDs spend more on sanitation than on public safety or streetscape and beautification (New York City Department of Small Business Services 2018).

## Trash and litter in urban settings

Why examine trash and litter in a thriving commercial and residential district?

The presence of street and sidewalk trash and litter is consistently cited as a key concern for local businesses in New York City's commercial districts. In New York City, street litter is mainly paper, plastics, and food-related waste (Fuchs and Culligan 2017). In Brooklyn Community District 2, which is where DBP is located, several of the budget needs requests for FY18 to New York City's planning department called

for either more enforcement of sanitation trash laws or more pickups for trash in litter baskets, indicating that the community believes there is a problem (Brooklyn Community District 02 2017).

Past studies have shown that the presence of trash and street litter tends to depress foot traffic and commercial activity, deterring shoppers and diminishing the vitality of street life, which often corresponds to a lower level of economic activity. Moreover, rainfalls wash trash and street litter into storm drains and sewers, which then wash out into area waterways and the sea, polluting both and affecting marine life. Floatable trash and debris mostly comes from street and sidewalk litter. New York City's Department of Environmental Protection (DEP) has sought to manage and control floatables for years under federal and state clean water laws, using catch basins and other strategies to keep this litter from flowing out to sea through the city's sewer system. Several of the catch basins are in the area of the DBP (New York City Department of Environmental Protection 2018). In addition, the presence of street litter and trash, particularly food-related trash, is associated with rats, which are a public health threat and are controlled by the NYC Department of Health and Mental Health (DOHMH) (New York City Department of Health, n.d.). Rat populations increase in areas with trash, especially food trash, and DOHMH monitors rat populations throughout NYC and attempts to eradicate them.

With respect to trash in New York City, the Department of Sanitation (DSNY) provides residential and institutional garbage and recycling collection services, while commercial carters service business clients. Residential service in New York includes multi-family housing, but not ground-floor commercial businesses in multi-family residential buildings. In addition, DSNY collects cardboard boxes, furniture, and other bulk items on its routes, while other bulk items like mattresses and appliances containing chlorofluorocarbons must be discarded following the disposal procedure outlined by DSNY (New York City Department of Sanitation 2018). Aside from regular garbage collection, litter baskets throughout the city are also serviced by DSNY. A previous report found that along the City's corridors in general, DSNY services litter baskets anywhere from twice to twenty times a week (Fuchs, MacQuarrie, and Poddar 2017). DSNY has also outlined new methods to achieve their goal of making New York the "cleanest largest city in the U.S.," including the recognition of the need to service litter baskets during weekends and holidays (New York City Department of Sanitation 2016). As of 2017, the agency reinstated Sunday and holiday service for litter baskets; 20 basket trucks were added, resulting in service of an additional 5,400 baskets (New York City Department of Sanitation 2017; Mesa, N., et al. 2018).

Related to these issues is the activity of commercial waste haulers in the area. While the DSNY is responsible for residential waste pickup and street pickup, private businesses hire commercial carters to take away their trash and recycling. According to New York City regulations, commercial businesses are required to hire a private carter to collect their waste. Alternatively, they can register as a self-hauler with the Business Integrity Commission. Trash for private pickup should be located on the sidewalk against the building, not on the curb or blocking the gutter (City of New York, n.d.). Violations can result in fines for the commercial establishment. In addition, DSNY has set up enforcement routing programs where enforcement agents patrol commercial areas looking for dirty sidewalks and failure to clean 18 inches into the street. If commercial businesses do not comply, a Notice of Violation may be issued, with fines ranging from $100 to $450 (New York City Department of Sanitation, n.d.; Mesa et al. 2018).

The commercial waste-carting industry, regulated by NYC's Business Integrity Commission (BIC), has come under intense criticism for truck traffic through residential and other areas as well as multiple and inefficient pickups in areas. Local elected officials, community organizations, and environmental groups for years have criticized these patterns as contributing to local air pollution, safety hazards, traffic, and noise. Recent legislation passed by the New York City Council aims to address some of these concerns, but is acknowledged to be just the "first step" (Greenfield 2018).

A model of current street litter policies was developed in the Fuchs and Culligan study (2017). That research found that certain community characteristics—including neighborhood, demographics, zoning, and proximity to public spaces—affect the presence and absence of street litter. The implementation of the City's policies to reduce street litter on a block (e.g., the presence of trash or recycling bins and frequency of trash pickup and street sweeping) can also vary by community. Street litter may tend to accumulate along certain streets, while particular parts of streets and sidewalks may also attract litter and trash. This all may ultimately affect the type, source, and quantity of street litter (Fuchs and Culligan 2017). Trash begets trash—where there are overflowing trash receptacles on sidewalks, buildups, collections that are delayed, trash in tree pits, and high population density, trash and litter may accumulate and bring with it all the effects on water quality, rats, and neighborhood livability outlined above (Boren and Terruso 2018).

To date, collecting data for both of these neighborhood concerns has required human surveyors to manually observe and tabulate street litter and trash as seen on sidewalks and storm drains on various days and times (Fuchs and Culligan 2017). The DEP developed a methodology to measure floatables caught in the sewer system, but this does not extend to the street and neighborhood level (New York City Department of Environmental Protection 2017). For waste-hauler traffic, the data has often been anecdotal. The data sources are limited in time and scope. The question we are examining is whether the technology being deployed by the participating start-ups in The Circular City program in Downtown Brooklyn may provide an alternative way to collect data that could be more comprehensive and that could prove useful to the Downtown Brooklyn Partnership and its members, as well as city agencies such as DEP, DOHMH, DSNY, and BIC. Could these technologies allow start-ups, academia, and urban tech professionals to organize, analyze, distribute, and implement data systems that create value in terms of improving resiliency and sustainability in Downtown Brooklyn?

### Research questions: what is the value of circular city data for resiliency and sustainability goals

- Could the data the start-ups are producing offer value to achieving resiliency and sustainability goals? How? And could data from city agencies including the Departments of Environmental Protection, Sanitation, Health and Mental Hygiene, the Business Integrity Commission, and the Economic Development Commission offer value to the start-ups?
- Do these agencies (including the DEP, DOHMH, and DSNY) have the capacity to use and integrate the data?
- Does the DBP/BIDs have the capacity to use the data? How could it be useful with the DBP's commercial partners?

- Are there other local community-based groups that would find it useful? Community Board?
- What other analyses could be done with the integrated data?

**Research gaps:**

- Can the data be integrated onto a platform?
- How to handle different times of data collection?
- What about the weather data? Can that be integrated?
- Would this have value in other neighborhoods? Business districts? Residential areas? Could it be scaled up?
- What else?

Specifically, the main research question then becomes: How can we (start-ups, academia, and urban tech professionals) organize, analyze, distribute, and implement data systems which create value in terms of improving resiliency and sustainability in Downtown Brooklyn?

The research will aim to understand the value of data by exploring recurring sub-themes such as the following:

**Data and quality:**

- Building upon protocols already established in Fuchs and Culligan's DEP study (2017), the data collected should include categories, sources, locations, and weather conditions .
- Categories would include types of trash/litter, such as paper cups, plastic bottles, bulk trash like furniture, and construction waste.
- Sources that could be identified would include food stands, restaurants, and grocery stores.
- Locations would include tree pits, how close to the street/where on the sidewalk, storm drains, around retail and food establishments, near or in public areas such as parks or plazas, and proximity to schools.
- Weather conditions would be contemporary with the collection of the other data, and would include rain and wind conditions.
- A survey of the data that could be collected would then also have to evaluate the quality and reliability of the data.

**Resilient ecosystems and environment:**

- Understanding how Business Improvement Districts can be more prepared (through the use of data) to deal with problems surrounding resiliency in their local communities.
- Exploring key trends on resiliency through current data of city agencies, for instance, in environmental-impact reviews and assessments.
- Exploring possibilities for the data provided by start-ups to be relevant in real estate and commercial buildings/stores, comprising aspects such as asset pricing, infrastructure conditions, amortization, and upkeep of buildings and neighborhoods.

**Resiliency of transportation networks:**

- Understanding how real-time street-level data analytics could support resilient transportation networks. Areas could include: freight and delivery trucks, waste management vehicles, shared vehicles, and multimodal transportation such as bikes and pedestrians. Key areas include parts of a streetscape that are vulnerable to accidents with pedestrians and efficient traffic management in downtown Brooklyn during peak/off hours.

**Resiliency of waste management/trash collection systems:**

- Exploring possibilities of better tracking litter, trash, and waste management systems in Downtown Brooklyn.

**Analysis of potential roles for start-ups' data**

The role of start-ups as primary sources of change is key within the system. By the end of this research project, there should ideally be a way to show how each of these start-ups are able to create value in the circular city, as discussed above. However, it must be noted that the objective to find value is not start-up-centric; rather, it is process-centric: i.e., how the act of data exchange leads to value which in turn improves the process of resiliency. While the paper analyzes data sets from start-ups, the underlying main objective is to understand the value of having data-exchange processes.

The three tech start-ups who are involved in this pilot are Numina, Citiesense, and CARMERA.

Numina

The potential areas where Numina may be able to contribute with regards to real-time data analytics for waste management and resiliency are several.

Presence of trash/litter: Numina's system captures visual data correlated with time that could be very relevant to the litter/trash efforts for the BIDs, DEP, DSNY, and DOHMH. Its images are clear, and its system for quantifying data is robust. For example, the system can spot bags of waste that are put out for pickup as well as when and for how long they sit before being collected. The system may be able to capture data on litter that is found on the ground or curbside next to the bags and bins. This could show where there may be overflowing bins, what times of day the bins would be overflowing, the quantity of the overflow as well as the location, identify any hot spots for the trash, and the degree to which more trash accumulates, in what timeframe, in proximity to the bags and bins. This potential is not necessarily limited to waste bins but could also include other locations like catch basins, tree pits, outside food and retail establishments, and near schools and parks that fall within Numina's range.

Another useful data point that may be possible to view and quantify would be the type of trash and litter that is found. For example, it would be very useful to be able to gather data on whether the litter was characterized as plastic or glass bottles, which are recyclable—a strategy could be developed to target

them. It would also be useful to know whether there are issues with bulk trash and dumping in any of the areas, for example from construction and demolition debris, as that might indicate a need for city agencies to step up enforcement.

The length of time between disposal and pickup would be another helpful data point. This could extend to trash receptacles as well as litter or bulk trash that is found on the sidewalk. How much time passes between when the trash/litter is left and it is cleaned up?

The overall cleanliness of the street could be assessed at different times of day and different days of the week. This would be a useful data point and could be compared with DSNY's regular visual self-assessments, providing reliable and more extensive third-party data verification. This data would be useful for DBP in working with the DSNY on the area.

The varying characteristics of pedestrian traffic, as well as times of day in which it occurs, could be measured and compared with the incidents of trash observed. Potentially these could demonstrate whether pedestrians are deterred from areas with trash, which may provide useful information for retailers. Pedestrian analytics could have several benefits, such as aiding DBP waste strategies and providing evidence to advocate for changes in service levels. They may also indicate whether trash bins are in the best locations for pedestrians, as well as give clues on pedestrian littering behaviors.

With respect to traffic and noise, the system should be able to track the presence and activities of commercial carters in the area, which routes they may be taking, and how they may affect livability.

The presence of rats and other vermin could also be detected, which could work with DOHMH's existing maps and data as well as show trouble spots that require additional attention. Much as Numina already can track vehicular traffic and hot spots, it could potentially spot vermin patterns.

Weather data could be integrated and compared with the other trash data to find patterns in litter accumulation. For example, rainfall and wind speed could be correlated to determine whether additional pickups or street or sidewalk cleanings would be needed.

Among the potential strengths of Numina's system is the possibility of collecting better quality data around the clock. This would be much more efficient and less labor intensive than the methods used today. It would also provide many more data points to assess littering patterns.

Potential weaknesses include the need for assessment of the locations for the best data. Are the spots within range of the Numina system the right spots to reflect the needs for the area?

The opportunity exists here to have the capability to collect real-time data from the relevant locations so as to identify correlations and causations that may then lead to better management and information surrounding trash and litter in this busy commercial and residential area. There is the potential as well for the information to be integrated with Citiesense's platform.

How the data that already exists from city agencies could be integrated in to this system would also need to be assessed.

### Citiesense

Citiesense has map-based features to help community organizations like BIDs advance the neighborhood improvement process. The start-up organizes neighborhood data about zoning, flood zones, properties, streetscapes, and other public spaces through visualization on a map for any area of the city, such as specific business districts. Citiesense promotes open data usage, and could be a rich platform to integrate existing data with new data that may be collected from Numina or CARMERA. Within this platform, some of the local and public data layers which could potentially be of interest with the waste management and resiliency theme are listed in the table below.

**Table 1:** Local and Public Data Layers

| **Local Data Layers** | **Public Data Layers** |
|---|---|
| • Business & Attractions<br>  o Shopping<br>  o Dining & Nightlife<br>  o Education<br>  o Industrial<br>  o Hotels & Event Venues<br>• Services<br>• Neighborhood Amenities<br>• Commercial Space Usage<br>• Development Activity<br>• Streetscape Assets & Street Conditions<br>• Local Security Reports | • Local Policy Zones<br>  o Business Improvement Districts<br>  o Commercial Overlay Districts<br>  o Zoning<br>• Demographics<br>  o Housing Data in this Census Tract<br>  o Population in this Census Tract<br>  o Employment and Work data in this Census Tract<br>  o Households in this Census Tract |

Strengths of working with Citiesense include the potential for integrating economic and population data along with business types and residential data in the area, and to manage local data as a community of neighborhood stakeholders. It is searchable in multiple ways.

A potential weakness is that it does not have real-time data, but it can connect to real-time data sets via an API. Considering this, it is worth examining the potential for these connections and how they would relate to data that does not change in real time, such as demographics and zoning.

Most important, it is worth examining how data collected from both Numina and CARMERA could be integrated. This is perhaps the greatest opportunity, and could yield important insights over time. Such integration could possibly show impacts of trash/litter data on economic data, for example on pedestrian traffic and retail. It could also potentially demonstrate correlations with health tracking in residential and commercial areas, for example with DOHMH's data on rats and other environmental data. It's also possible that DEP data on storm drains could be integrated with the Numina data to show hot spots for contamination and litter accumulating in storm drains. It would also be interesting to assess whether data on parks and trees could be relevant to the picture of the street and neighborhood life. Last but not least, integrating demographic and zoning data could also identify whether there might be hotspots or unequal enforcement that would correlate with commercial or residential areas that are less well-off economically.

### CARMERA

CARMERA is a street-intelligence platform for autonomous mobility. Its flagship product, CARMERA Autonomous Map, is a real-time high-definition mapping suite for autonomous vehicles (AV). As such, it captures data that could also be relevant to resiliency and sustainability efforts in the community.

In addition to data for its AV customers, CARMERA collects real-time update data for its maps independently, through a visual telematics service it provides high-coverage fleets such as delivery trucks. This professionally crowdsourced vehicular sensor network, which uses powerful but inexpensive roof-mounted sensors, continually gathers 3-D scene, change detection, and analytics data. Its machine-vision and geospatial-data pipelines extract imagery on street activities through tags and object identification systems that could also be integrated with Citiesense's platform. Unlike Numina, which has fixed sensors, CARMERA collects data from vehicles moving in the street. Its perspective thus is, in theory, more flexible, and could capture data that might be missed by the other systems, particularly in areas that might be of special interest but not within range of the fixed sensors.

The potential strengths of the CARMERA data are several. The pedestrian density patterns could include heat maps and expose any correlation with commercial carters, especially at different times of the day. This could pinpoint locations of pedestrian safety issues. Much like Numina, the data collected might include visual trash data, such as types of trash, as well as how accumulations of trash might dynamically affect pedestrian patterns. The roving nature of CARMERA's data-collection practices could be a real advantage for collecting relevant data, potentially providing a broad sweep. Such data might then be correlated with hot spots and storm drains, which would be more easily visible from a street-side perspective. This would pair well with Numina's capabilities and give a more solid overall view of the local conditions, patterns, and, potentially, their underlying causes.

CARMERA's data is collected regularly and would likely be more comprehensive and potentially more accurate than the manual methodologies that are used today.

A potential opportunity with CARMERA is that it could record the number of commercial trash haulers found on streets of Downtown Brooklyn along with time of day, depending on when their cameras are picking up information. In addition, as noted above, it could be integrated with Citiesense's platform to provide better analyses with demographic and other information.

## Next steps

Interviews are to be set up with representatives from the Downtown Brooklyn Partnership, city agencies, and Numina, Citiesense, and CARMERA. Of special interest will be assessing what data the city agencies may have to share with the three tech companies, as well as what they may be able to use to complement their current data and monitoring efforts. The next update of this research will reflect the results of those interviews.

Below are the working theories and conclusions that will form the basis for the next stage.

**Table 2:** Working Theories and Conclusions

| Start-up | City/DBP needs and challenges | Relevant start-up data that could be gathered | Potential results | Potential limitations/ open questions |
|---|---|---|---|---|
| **Numina** | -DBP: improving street experience for pedestrians to improve economic development, attract traffic<br><br>-DEP: tracking street/sidewalk litter to floatables so as to manage sewer systems & discharges<br><br>-DSNY: identifying hotspots and behavior above ground to keep neighborhood clean<br><br>-DOHMH: monitoring rats, identifying populations so as to take action and assess whether strategies are effective<br><br>-BIC: identifying commercial carter actions, congestion | -Pedestrian data<br><br>- Location of trash hotspots on sidewalks<br><br>-Timed conditions<br><br>-Weather conditions<br><br>-Possible sources of trash<br><br>-Presence of rats<br><br>-Presence of commercial carters and time of day<br><br>-Vulnerable intersections | -Better identification of the root causes and actual effects of street and sidewalk litter on the BIDs' areas<br><br>-Better tracking of street and sidewalk litter before it gets to catch basin<br><br>-More effective and targeted strategies to reduce litter and trash<br><br>-Better rat eradication efforts<br><br>-Ability to respond more rapidly and identify changing conditions<br><br>-Ability to identify any problem areas with commercial carters that could affect pedestrians and residents<br><br>-Could work citywide | -Not clear what it would take to integrate the data with agency systems and city data on the technical side<br><br>-Fixed cameras could have limited range or not be pointed at the right places<br><br>-City data at the street scale could be integrated with Numina data but not clear how robust it is |

**Table 2:** Working Theories and Conclusions *(Continued)*

| Start-up | City/DBP needs and challenges | Relevant start-up data that could be gathered | Potential results | Potential limitations/ open questions |
|---|---|---|---|---|
| **Citiesense** | -Same as above | -Platform could integrate zoning and demographic data with data from other start-ups to create a searchable set of data | -Strategies could be micro-targeted at the street level<br><br>-Data could be transparent and easy to use for community organizations, private sector, community board, agencies such as DEP and Planning<br><br>-Could work citywide | |
| **CARMERA** | -Same as above | -Street-level data would complement sidewalk data gathered above<br><br>-Dynamic views of pedestrian interactions with other data points<br><br>-Data on commercial carters traffic patterns and interactions with pedestrians, locations, times of day<br><br>-Could be more accurate data on storm drains than now possible to collect<br><br>Same for rats | -More efficient, reliable, comprehensive, and cost-effective data at the street level for the city agencies<br><br>-Could work citywide, scalable | -Not clear what it would take to integrate the data with agency systems and city data on the technical side<br><br>-Not clear how agency and city data could provide information to CARMERA— perhaps for known events and permitting |

## Conclusion

One of the most exciting opportunities here is for the three tech start-ups to work together and produce an entirely new data set that would potentially have more robust, accurate information, over a more expansive time frame, and with layers of social, economic, and demographic information for downtown Brooklyn integrated with it. In addition, if data from city agencies could be integrated, such a powerful set of data could test the effectiveness of waste management policies, operations, and enforcement along with public health efforts and how they affect Downtown Brooklyn. Real-time integrated street-level data analytics could support the development of more effective street waste management systems in downtown Brooklyn, in one of the most vibrant and growing commercial and residential areas of the city. The tools the start-ups are developing have not existed before, and, working in tandem, could very well upend data and structural obstacles that, to date, have stymied goals for clean streets and improved waterways.

Moreover, should this model prove successful, it could be applied to other commercial and residential districts in New York City, as well as other cities. Such a data-collection model, with its real-time tracking of pedestrian traffic, street litter, and waste management integrated with demographic, zoning, and other data, would mark a tremendous leap. It would be a dramatic shift from the current manual and intermittent data-collection efforts on waste and litter, which are subject to errors ranging from data-collector bias to inexperience to simple human error. Reliable, comprehensive data could direct street and sidewalk cleaning initiatives to be much more effective and efficient, and remove doubts as to the causes and sources of litter, thereby enabling the BIDs and surrounding communities to target the root causes, craft public education and other campaigns, and measure results faster and more cheaply. It would also enable city agencies to hone their programs to be more effective, whether the programs are rat eradication, trash collection and enforcement, pedestrian safety, or keeping storm drains and waterways clean.

The development of these analytics and systems have the potential to mark the early beginnings of a transformation in the quality of life, resiliency, and sustainability of city streets. Past efforts have been stymied by a lack of reliable data, and too much uncertainty around the patterns and causes of the accumulation of sidewalk and street litter, their impacts on storm drains, their public health impacts, how they may affect pedestrians and other users of a commercial and residential neighborhood, and what impacts might be on local businesses and property values. Solid data and analytics will lead to understanding the dynamics and causes of street litter and commercial carter traffic impacts. With this understanding coming from a reliable set of data, both community and business leaders and the city agencies charged with enforcement and operations to improve neighborhoods can work together more effectively. The result at the end of the day would be a more vibrant street life, better public health outcomes, cleaner waterways, safer pedestrian zones, and an improved retail and local business experience. It might all start in Downtown Brooklyn, as data sets are brought together and developed in this project.

## References

100 Resilient Cities. n.d. “Frequently Asked Questions (FAQ) About 100 Resilient Cities.” Accessed February 8, 2019. http://www.100resilientcities.org/FAQ/#/-_/.

Boren, Michael and Julia Terruso. 2018. “Trash Tirade.” *The Philadelphia Inquirer*, February 22, 2018. http://media.philly.com/storage/special_projects/philadelphia-trash-waste-garbage-complaints-philly-311.html.

Brooklyn Community District 02. 2017. “Statements of Community District Needs and Community Board Budget Requests, Fiscal Year 2018.” January 2017. https://www1.nyc.gov/assets/planning/download/pdf/community/community-portal/statement_needs/bk02_statement_2018.pdf.

City of New York. n.d. “Commercial Waste Disposal.” Accessed February 8, 2019. https://www1.nyc.gov/nyc-resources/service/1425/commercial-waste-disposal

Downtown Brooklyn Partnership. n.d. “About Us.” Accessed February 8, 2019. http://downtownbrooklyn.com/about.

Downtown Brooklyn Partnership. 2018. “Downtown Brooklyn.” http://s3.amazonaws.com/downtown-brooklyn/imgr/Why-Downtown-Brooklyn_DBP-2018.pdf.

Fuchs, Ester and Patricia Culligan. 2017. “Stopping Trash Where it Starts: A Project to Mitigate Floatable Trash in New York City Waterways through Targeted Street Litter Reductions.” Columbia University’s School of International and Public Affairs and Data Science Institute, for the New York City Department of Environmental Protection, March 2017.

Fuchs, Ester, Ashley MacQuarrie, and Debashree Poddar. 2017. “Promoting a Cleaner and Healthier Harlem: Reducing Street Litter in the 125th Street Business Improvement District.” Columbia University’s School of International and Public Affairs for the 125th Street Business Improvement District, July 2017.

Greenfield, Nicole. 2018. “New York City Is Finally Cleaning Up Its Commercial Garbage Industry.” NRDC.org, October 17, 2018. https://www.nrdc.org/stories/new-york-city-finally-cleaning-its-commercial-garbage-industry.

Mesa, N., Y. Shimabukuro, D. Poddar, F. Borges, X. Fonseca-Morales, and E. Font. 2018. “Towards a Clean and Healthy Harlem: Street Litter in Central Harlem.” Unpublished manuscript, July 2018.

New York City Department of Environmental Protection. 2017. “Draft Work Plan.” August 2017. https://www1.nyc.gov/html/dep/pdf/water_sewer/draft-floatables-work-plan.pdf.

New York City Department of Environmental Protection. 2018. “NYC Stormwater Management Program.” August 1, 2018. http://www.nyc.gov/html/dep/pdf/water_sewer/NYC_SWMP_Plan_Full-08012018.pdf.

New York City Department of Health. n.d. “What Contributes to Rats.” Accessed February 8, 2019. https://www1.nyc.gov/site/doh/data/health-tools/rats-what-contributes.page.

New York City Department of Sanitation. n.d. “Cleaning Laws.” Accessed February 8, 2019. https://www1.nyc.gov/assets/dsny/site/resources/streets-and-sidewalks-laws/cleaning-laws.

New York City Department of Sanitation. 2016. “2016 Strategic Plan.” https://dsny.cityofnewyork.us/wp-content/uploads/2017/10/2016SP.pdf.

New York City Department of Sanitation. 2017. “2016 Strategic Plan: 2017 Progress Report.” https://www1.nyc.gov/assets/dsny/downloads/pdf/about/newsletter/Strategy_Plan_Update_6.15.17_Final.pdf.

New York City Department of Sanitation. 2018. “2016 Strategic Plan: 2018 Progress Report.” https://dsny.cityofnewyork.us/wp-content/uploads/2018/07/Strategy_Plan_Update_2018_final.pdf.

New York City Department of Small Business Services. 2018. “NYC Business Improvement District Trends Report FY ’17.” https://www1.nyc.gov/assets/sbs/downloads/pdf/neighborhoods/fy17-bid-trends-report.pdf

The City of New York. n.d. “OneNYC: The Plan for a Strong and Just City.” Accessed December 3, 2018. http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf.

Romero-Lankao, P., D.M. Gnatz, O. Wilhelmi, M. Hayden. 2016. “Urban Sustainability and Resilience: From Theory to Practice.” *Sustainability* 8, no. 12 (2016): 1224.

World Commission on Environment and Development. 1987. “Our Common Future.” Oxford: Oxford University Press.

# Conclusion

André Corrêa d'Almeida, *Columbia University and ARCx - Applied Research for Change*

### The Value of Circular City Data

Though we talk of an overabundance of data, it is often still not visible or tactically wielded at the local level in a way that benefits people. The abundance of data available, the vast differences in capacity across organizations to handle it, and the growing complexity of urban challenges provides an opportunity to test how principles of circular city data can help to establish new forms of public and private partnerships that make cities more economically prosperous, livable, and resilient.

Circular data is an effort to build a safe environment whereby start-ups, city agencies, and larger firms can produce, access, and exchange data, as well as business insights, through transaction mechanisms that do not necessarily require currency, i.e., through reciprocity.

This first volume of *The Circular City Research Journal* brought together scholars from Columbia University, Cornell Tech, and New York University (NYU) to explore and answer three specific questions. First, how was New Lab's The Circular City program idealized, designed, and implemented to operationalize, experiment, and test, at the local level, the promises of circularity? This question is answered using the case-study methodology with a focus on three key aspects: (i) New Lab's unique position to take on this initiative, (ii) the importance and role of public-private partnerships and the need to reimagine these partnerships, and (iii) the quest to find the value of circular data as a medium for collaboration and circularity.

Second, how can New Lab's The Circular City program be scaled up in New York City and replicated in other U.S. cities and around the world? This question is answered by developing a detailed stakeholders' analysis and looking into the conditions of success and risks associated with this type of program.

Third, what is the value of circular data to address key urban challenges in New York City (NYC) related to economic growth, mobility, and resilience? This question is answered in three connected but independent research papers developed by three different research teams.

While the introduction to this research journal offers definitions for both circular city and circular data, the three theme-specific research papers positively support the hypotheses that circular data can help establish new forms of public and private partnerships and make cities more economically prosperous, livable, and resilient. Columbia University's Nilda Mesa leaves no doubt in her conclusion about the value of circular data for resilience and sustainability:

> *One of the most exciting opportunities here is for the three tech start-ups to work together and produce an entirely new data set that would potentially have more robust information, more accurate information, over a more expansive time frame,*

> *and with layers of social, economic and demographic information for downtown Brooklyn integrated with it.*

Cornell Tech's Arnaud Sahuguet follows the same positive path when, in his paper about circular data and mobility, he states that "[s]tart-ups and cities need to work together." In fact, he goes further to suggest that, "[i]n an ideal scenario, all relevant data sets should be shared with the City."

In their paper about circular data and economic development, NYU's Stefaan G. Verhulst, Andrew Young, and Andrew J. Zahuranec explain what this collaboration means in practical terms and its value. Their five value-vectors—situational analysis, cause-and-effect analysis, prediction, impact and value assessment, and ecosystem support—can be used by businesses seeking to increase revenue and market share, optimizing exciting processes, and/or innovating.

However, in the same paper, the NYU team educates us on the risks of this circularity when they say:

> *The generation, sharing, and use of circular data are not without risks. An up-front mapping and consideration of risks across the data lifecycle—Collecting, Processing, Sharing, Analyzing, Using—can allow practitioners to design programs from the outset in a way that is well-positioned to overcome or mitigate those risks.*

While the three research hypotheses have been tested and positively supported, certain conditions for success need to be met to enable the full potential of circular data and acceleration of innovation. While the NYU team highlights five conditions for success—Problem and Demand Definition, Capacity and Culture, Governance, Partnerships, and Risks Mapping—Cornell Tech's Sahuguet puts the emphasis on the conditions for matching data demand and supply. He creates two groups of conditions: conditions for start-ups and conditions for cities.

Throughout this quest to find the value of data as a medium for collaboration and circularity, these three research papers only tested hypotheses and offered preliminary insights on the value. Sahuguet leaves no doubt about some of the challenges with the concept of circular data: "Despite lots of research on the topic, there is very little we can say quantitatively about the value of data sharing." This is partly why the scale-up of the program is not only an opportunity presented by this first round of results but a necessity to further monitor the value of circular data. Nevertheless, data is just the beginning, a sort of raw material. What will matter in practical terms are the models for machine-learning algorithms that will power a hypothetical large shareable data pool. As Nilda Mesa puts it, "The development of these analytics and systems have the potential to mark the early beginnings of a transformation in the quality of life, resiliency, and sustainability of city streets."

The Circular City program is still in its early stages and circulation of data, co-development, and co-creation are just beginning. Despite all the opportunities and pathways described in the case study, no systematic circular-data mechanism or technology was built in this time period. Moreover, this ten-month grand experiment relied on the participation of a relatively small number of stakeholders. For

example, New Lab houses over 100 start-ups and only three participated in this first phase of the program. The participation of other start-ups will require an expanded and more complex set of incentives for participation. On the other hand, one could argue that a circular city data program will have a stronger impact in non-data-rich areas, something Downtown Brooklyn is not.

Sahuguet sets the stage and asks the question that makes us all dream:

> *Mobility is at the inner core of our urban lives. What used to be the exclusive preserve of cities and governments is now being disrupted by the private sector and its permissionless innovations. Data-driven decision-making applied to mobility requires solid mobility data. Unfortunately, such data is often fragmented and hard or pricey to assemble. What if such data could be shared or, rather, circulated between stakeholders?*

### Innovation Roadmap: Tools for Implementation and Scaling-up of a Circular City Program

The four papers together offer a series of practical tools that can be purposely sequenced and used to implement and scale-up circular city programs in other U.S. cities and around the world.

**Table 1:** Tools for Implementation and Scaling-up of a Circular City Program

| Specific Purpose | Suggested Practical Tool | Paper in the Journal |
|---|---|---|
| -Conceptualize a data market and think in terms of problem appraisal, demand, supply, and value proposition/creation. | -Data Value Canvas<br><br>-Demand and Supply Framework<br><br>-Data Use/Results Matrix | -Circular Data for a Circular City: Value Propositions for Economic Development<br><br>-Circular Data for a Circular City: Value Propositions for Mobility<br><br>-Circular Data for a Circular City: Value Propositions for Resilience and Sustainability |
| -Analyze and categorize data sets that will be used to build a data market. | -Data Frameworks and Typologies<br><br>-Data Challenges Matrix | -Introduction to The Circular City Research Program<br><br>-Circular Data for a Circular City: Value Propositions for Mobility |
| -Describe participation expectations and perceived risks as well as design incentives schemes for a sustainable partnership. | Stakeholder Matrix | -The Circular City Program: The Case Study |

**Table 1:** Tools for Implementation and Scaling-up of a Circular City Program *(continued)*

| Specific Purpose | Suggested Practical Tool | Paper in the Journal |
|---|---|---|
| -Map short-term and long-term goals and align expectations across stakeholders participating in the program. | -Success Matrix | -The Circular City Program: The Case Study |
| -Provide a set of enabling conditions, risks, and challenges. Map the contextual variables most likely to affect the program and help define the conditions for program success. | -Periodic Table of Circular Data<br><br>-SWOT Analysis | -Circular Data for a Circular City: Value Propositions for Economic Development<br><br>-Circular Data for a Circular City: Value Propositions for Mobility |
| -Design a model of city-wide, public-private partnership. | -Governance Model | -The Circular City Program: The Case Study |
| -Visualize an innovation roadmap. | -Timeline | -The Circular City Program: The Case Study |

***

Since at least John Locke (1689) and Jean-Jacques Rousseau (1762), human thinking has understood the role trust, collaboration, and reciprocity play in the development of institutions and socio-economic models. At the onset of the 21st Century, Wright (2001) declared non-zero sums as the logic and driving force of human destiny.

Circular city and circular data matters for the future of cities because, while data abounds, resources to make sense out of it are scarce, people's needs are not being met, urban challenges are getting more complex, urban inequality is widening, and the world is in deep need of smarter ways of collaboration capable of establishing the local, regional, and global partnerships needed to build new and sustainable social, economic, and environmental models.

The working theory is that the act of trading and circulating data creates value. The data that may have been discarded, or is still being used, by the original generator may be transformed in new hands. The exchange may lead to new business insights, analyses, and/or be combined with other data to create yet more value for potential users who may not have been aware of the original data or were unable to use it in its original fragmented form. Similar to living systems, urban systems can be enhanced if the total pool of data available, i.e., energy, can circulate, be democratized and decentralized, and data analytics used widely and inclusively to positively impact quality of life.

The promise of abundant data is only as powerful as the collaborative platforms and analytical tools available to people and organizations to create shared and multiplied value from it.

## References

Locke, John. 1689. *Two Treatises of Government*. 10th edition. Chapter II, Section 6. Project Gutenberg. http://www.gutenberg.org/files/7370/7370-h/7370-h.htm

Rousseau, Jean-Jacques. 1762. *The Social Contract*. Translated by G. D. H. Cole, 1782. http://www.constitution.org/jjr/socon.htm

Wright, Robert. 2001. *Nonzero: The Logic of Human Destiny*. New York: Vintage.

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*Research Lead for Circular Data for a Circular City: Value Propositions for Mobility*

Dr. Arnaud Sahuguet has a passion to invent and build products that leverage technology to solve meaningful problems and have a large social impact. His goal is to empower people and organizations to be more productive and collaborative through innovation. He is currently the project lead for the Urban Tech Hub at the Jacobs Technion-Cornell Institute in New York City. Previously, he was the director of the Foundry@Cornell Tech, an in-house team of designers, product managers, and software engineers who collaborate with faculty to design, create, and build usable tools, platforms, and products. Before joining Cornell Tech, Sahuguet served as Chief Technology Officer for the Governance Lab at New York University, where he focused on civic innovation and open data; he spent eight years as a product manager for Google (speech, Google maps) and Google.org; and he worked for five years at Bell Labs research as a Member of Technical Staff. Sahuguet holds a PhD in Computer Science from the University of Pennsylvania, a MSc in civil engineering from École Nationale des Ponts et Chaussées, and a BSc from École Polytechnique in France.

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Stefaan G. Verhulst is Co-Founder and Chief Research and Development Officer of the Governance Laboratory (GovLab) at New York University, where he has built a foundation of research and practice on how to transform governance using advances in science and technology. Verhulst's latest work centers on how technology can improve people's lives through creation of more data-driven, evidence-based, and people-led forms of innovation and governance. Specifically, he is interested in the perils and promise of open data, data-collaboratives, blockchain, artificial and collective intelligence for problem solving, public service design, and policy making. He is a regular contributor to the Harvard Business Review, Stanford Social Innovation Review, apolitical, and various other academic and public interest outlets. He was recently selected as one of most influential global leaders in the area of digital government by apolitical.

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Andrew Young is the Knowledge Director at GovLab, where he leads research efforts focusing on the impact of technology on public institutions. Among the grant-funded projects he has directed are a global assessment of the impact of open government data; comparative benchmarking of government innovation efforts against those of other countries; a methodology for leveraging corporate data to benefit the public good; and crafting the experimental design for testing the adoption of technology innovations in federal agencies.

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Andrew J. Zahuranec is a research fellow at GovLab responsible for studying how advances in science and technology can improve governance. In previous positions at the NATO Parliamentary Assembly and National Governors Association, he worked on issues as far-ranging as election security, the commercial use of space, and the opioid epidemic. He has a Master of Arts in Security Policy Studies from the George Washington University and a bachelor's degree in Political Science and Intelligence Studies from Mercyhurst University.

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