Big Data Based Government Economic Monitoring (GEM) and Targeted Action

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Introduction

The U.S. Digital Accountability and Transparency Act of 2014[1] wase introduced as the first open data law focused on federal government expenditures. Accordingly, the accessibility and transparency of government financial information have been receiving great attention. However, strong doubts have been raised concerning the reliability of the Comprehensive Annual Financial Report (CAFR) (Walters, 2012). The key questions entail:

- *What are evaluation metrics for government policies and public services?*
- *Are the current measurements accurate, comprehensive, accessible, and useful to the public?*

Municipal governments are responsible to report timely and relevant information to the public. However, only few citizens possess the ability and knowledge to analyze the limited financial information provided by the government. Moreover, the public good is hard to measure since it is difficult to reflect operational performance in financial terms and the effect of current policies would mainly only be visible over the long-term. Governmental performance is not measured by profitability, instead, it is measured by the level of efficiency and effectiveness of service provided by the given funding. Many new indices of performance can be developed with exogenous data, for example, utilization of electricity or satellite pictures measuring illumination can be used to proxy for economic activity or in the opposite for workers staying at home. The

[1] https://www.cbo.gov/publication/44933

performance of the government is not only looking at the balance of the expenses to funding, but also towards many external factors traditionally such as per capita GDP, poverty rate, median household income, and unemployment rate, etc. These measurements can be expanded and re-defined, in the modern data environment.

Brown-Liburd, Cheong, Vasarhelyi and Wang (2019) argue that "the emergence of enormous disparate data sources, available in a multitude of alternate formats, and on very different devices is leading to a business process revolution ... a new approach in which these technologies are used to replace outdated blanket government intervention programs in needed." Joint analysis of exogenous (Brown-Liburd and Vasarhelyi, 2015) and government-given data could improve the interaction between the government and the citizens as well as improve the management of municipalities. Information giants such as Facebook, Google, and Amazon gather their data from a large number of users. This 'big data" enables them to develop predictive behavioral models for commercial and business purposes (Brown-Liburd et al., 2019; Zuboff, 2019). Municipal governments can adopt GEM methodologies creating a new type of smart e-government closer to citizens' lives. By combining traditional budgetary and financial data with exogenous data from many sources, GEM can assist municipalities to target programs and funding where it is needed most. In particular, GEM will serve to both create new forms of measurement and evaluation indices as well as to provide continuous assurance to the financial information provided by government agencies (see Figure 1). It can also serve as an agent to potential targeted action on narrow domain social pathologies.

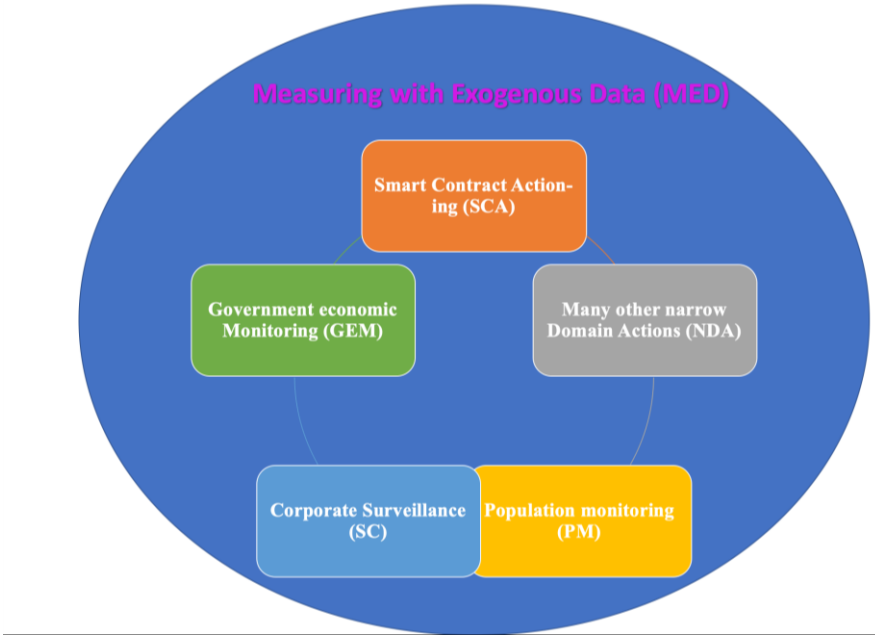


Figure 1: Measuring with exogenous data methodologies (MED)

By measuring socioeconomic factors that were not previously measurable, and strategically dynamically reallocating the budgets, the government can foster a wide range of social support programs. These social programs may provide higher social welfare to the community. The usage of data-driven models and exogenous data by GEM can support municipalities to develop a dynamic social network system. Specifically, the government can be able to collect more relevant information, effectively analyze the information, and adjust the current policy to lead better governmental support to the community.

Limitation of Current System

Local governments prepare their financial data by, in general, following the GASB guidance and local regulation. A local resident typically belongs to multiple governmental units (e.g. county, city, municipality, school district, etc.). Local government decisions on the budget will reflect the program commitments and policy priorities of local administration. The gap between the budget and the actual financial outcome of financial results may be large. Budgets often present many manoeuvers to pretend they are balanced. Technological advancement has been slow in the practices of local governments. Municipal decision-making processes need a broader set of principles and measurements to satisfy the needs of their local residents (Ganuza et al., 2014). Furthermore, the budgeting process needs administrators to have the most timely and relevant

information about what their community needs. In New Jersey, the Office of Management and Budget (NJ OMB) is the main agency which plans, develops, and oversees the execution of the annual budget (Keevey, 2017). NJ OMB provides their vision and purpose of budget allocation on their annual report[2]. However, as it often occurs in many localities, the objectives of the budget allocations do not seem to have been adequately met. According to the recent survey conducted relative the Newark education systems (HYA Executive Search, 2018), a large discrepancy exists between the perceptions of administrators, student, and teachers on the quality of education and the announced vision of the future. Without an in-depth understanding of the community, how could a municipal government come up with effectively targeted budget plans?

There is no agreed-upon municipal performance measure since it is hard to measure the social value of the money spent by the Government (Joyce, 1996; Barrett, 2013). Especially, the efficiency and effectiveness of social programs budgeted by the municipal governments (public sector) are nearly impossible to evaluate. These evaluations are commonly used in the private sector (Rivenbark and Kelly, 2006). The outcome could be determined by the desired benefits (e.g. marginal utility) given to the beneficiary by the executed budget. The lack of methodologies to demonstrate and measure benefits undercuts the ability to assess the budgetary performance (i.e. deviation between the budget and the executed outcome) of the municipal government. Accordingly, studies had focused on the efficiency and effectiveness of the budgeting process rather than the actual outcome (de Lancer Julnes and Holzer, 2001; Kelly and Rivenbark, 2003). For instance, the NJ OMB annual report provides very few quantitative measures of the executed outcome. Accordingly, municipal governments typically implement Participatory Budgeting (PB), a concept from the municipal government of Porto Alegre in Brazil, to mitigate these issues (de Sousa Santos, 1998). Wampler and Hartz-Karp (2012) state there is "no standardized set of best practices" of governance and that more measures relating to government performance could enhance the municipalities ability to adopt better policies while inducing more budgetary participation from the communities.

Moreover, there are large variations in financial report quality. In general, audited financial reports are more likely to be a high-quality financial report. However, local governments have limited budgets and lack financial professionals especially in small local governments. Also, the government can have latency issues related to financial reporting which will have a direct effect

[2] https://www.nj.gov/treasury/omb/publications/20budget/pdf/FY20GBM.pdf

on the next year budget (i.e. lack of timeliness). Lack of an authorized supervisory entity also affects the quality of municipal financial reports. The Governmental Accounting Standards Board (GASB) suggests that generally accepted accounting principles should be used by state and local governments. Since local governments are not required to follow GASB statements, these are frequently not used hampering comparability and good reporting.

Therefore, many variances occur during the budget execution phase. According to the SNAP (i.e. food stamps) Activities Report of 2016, the total dollar amount of fraudulent activities is estimated at 216 million dollars (U.S. Department of Agriculture, 2017). These fraudulent activities were conducted by both the recipients and retailers of the SNAP programs. Furthermore, the case of the City of Dixon, one of the biggest municipal scandals in the U.S., demonstrates the possibility of fraud by administrators who oversee budget execution. Rita Crundwell, former controller and treasurer of Dixon, had embezzled $53.7 million from the city of Dixon for over twenty-two years. Since there existed no means to detect the fraudulent financial reporting, the municipality has suffered from the employee embezzlement, false expenses, and other nefarious activities.

The problem of poor budgeting and reporting, resembling business reporting prior to the Securities Act of 33/34[3], is widespread. Citizens have poor reporting and local managers inadequate information to base their decisions. Modern data availability can create close to real-time measurements of key variables and guide administrators towards dynamic budgeting and direct action on social pathologies. Although reporting in the government arena is substantially more primitive than in the business world there are improvements that can be made that could make it more timely, detailed, and accurate. In the following sections, we will introduce how GEM could address these issues in detail.

Measurement with Exogeneous Data (MED) and Government Economic Monitoring (GEM)

[3] https://www.sec.gov/answers/about-lawsshtml.html

MED and GEM

Government Economic Monitoring (GEM) is an instantiation of MED directed toward public management, disclosure, and assurance. Measuring with exogenous data can be applied for business, for population control, for corporate surveillance (Zuboff,2019) and many other domains. Human and automata activities leave a large number of tracks on the environment that currently are recorded and often accumulated in many locations. This new phenomenon of data collection and storage can be associated to analytic methods to identify, record, analyze, and predict behavior. It can be used to affect this behavior and change the nature of activities.GEM is a data-driven and preventive conceptual model to first measure the societal socioeconomic status and secondly to provide means for the government to establish targeted social services for those who need them the most (Brown-Liburd et al., 2019). GEM utilizes big data and exogenous data analytics to provide the most timely and relevant information. GEM is composed of three phases (see Figure 2): first measuring the socioeconomic status by MED, second, analyzing the information given by MED, and third, providing analyzed information to the action agents (e.g. Non-profit Organizations, government agencies, and etc.). In specific, GEM captures the current socioeconomic status of the region in question. This differs from the current economic measurement methodology (e.g. GNP, GDP) which are very coarse, inaccurate, and delayed (Fleurbaey and Blanchet, 2013). These traditional socioeconomic measurements heavily rely on periodical surveys inefficient and inaccurate (Mellon, 2013).

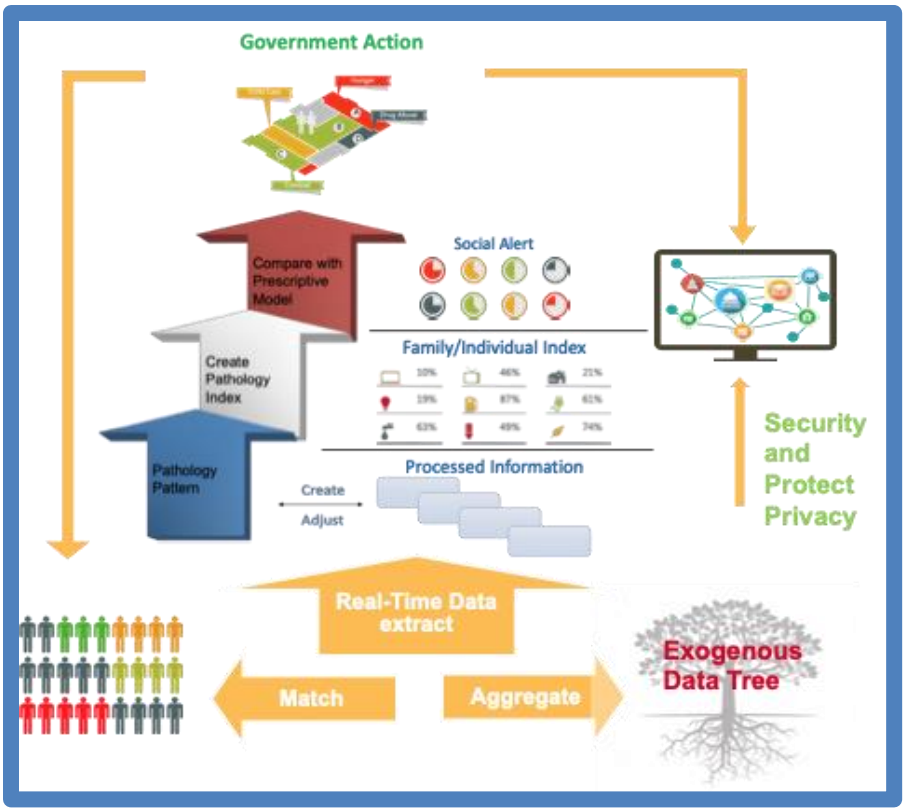


Figure 2: The GEM Dynamic Processes (Brown-Liburd et al, 2019)

Researchers are developing many new measures which rely on the big data and technology used by digital giants and advertisement companies (Ripberger, 2011; Stephens-Davidowitz, 2017). GEM can utilize and expand on similar methodologies used by the private sector, however, it creates socioeconomic measures which are the basis to identify social pathologies. Since MED may provide continuous and broad categories of socioeconomic measurement, the government could better identify social pathologies existing in the community. For example, using multiple sources of data, children neglect, suicidal tendencies, wife abuse, and opioid addiction, could be identified and monitored, with an expected reasonably high degree of accuracy. Additionally, governments could establish flexible forward-looking budget plans as well as dynamic budget execution dealing with some of these social pathologies. For example, infrastructure construction funds could be articulated with particular short-term programs and made conditional on timely economic indices. Timely data generation and monitoring provide more accurate economic measures as well as more reasonable predictions.

These methodologies can enable the government to obtain a more precise and detailed continuous measurement at the Family Block [4] (FB) level. This may make socioeconomic measurement less dependent on aggregated periodical surveys or untimely census measurement. Armchair auditors (O'Leary, 2015; Dai and Li, 2016) could utilize these measurements as means to evaluate, on close to a real-time basis, the discrepancy between the budget plan and executed outcome and other proxies of targeted government action. Such a monitoring process could facilitate municipalities to adjust policies based on the feedback given by third parties (e.g. NPO, citizens). In further sections, we will discuss how GEM identifies social pathologies and the benefits of MED and GEM to municipal governments.

GEM for Newark: Dynamic Newark, Dynamic Governance

In 2018, 28.3 percent of Newark residents were reported to be in poverty (U.S. Census Bureau, 2018). In contrast, in 2017, Newark saw only a 1.2% increase in its population while having a 13.1% increase in its median household income[5]. Several events have occurred. For example, Audible[6], a subsidiary of Amazon, has been established with headquarters in Newark. Audible, is the largest audiobook enterprise, in a rapidly growing market. They are an example of a transformational urban turnaround of Newark. Thus, Newark is a city which is underdeveloped but potentially developing at a fast pace. The essence of urban development can be better achieved by a flexible urban development plan based on first a rapid accurate gathering of information and secondly, it's reporting to the appropriate planning and executive entities (Thompson et al., 2016). This could introduce dynamicity to the municipality governance process mainly composed of three processes: planning, execution, and feedback. Socioeconomic status can be measured at a FB, regional, and municipal levels. The ensuing discussion focuses on how this measurement could improve the decision-making process at the municipal level.

Traditionally each process is a sequence of events/actions with large time lags between processes. For example, the planning process will mainly rely on the information (e.g. census, survey) derived at best from the previous fiscal year. Plans for budgeting will be based on this

[4] For advertising purposes, the large digital player tries to identify how individuals cluster together, either individually, family groups, closely related partners, participants of common endeavors, etc. These groups contingent on the purpose of the grouping are hereby called family blocks.
[5] https://datausa.io/profile/geo/newark-nj/
[6] https://www.audible.com/about/community/

outdated information which will limit the capability of the municipality to adjust to any more relevant and timely policies. By introducing rapid measurements, the municipality could maintain a real-time survey and census (i.e. socioeconomic measurement) of its region. Real-time information can lead the government to yield forward-looking policies. Especially for cities such as Newark which are dramatically changing, forward-looking policies are crucial to sustaining the growth of the city. Outdated information will lead to the mismatch between the demand of the actors of the community (e.g. citizens, companies) and the policies implemented by the government.

While the government agency executes its plan, big data measurement technologies can provide continuous feedback. This dynamic governance process allows the region to quickly, promptly and efficiently respond to citizen needs. To sum up, dynamic governance, compared to static governance (i.e. planning budgets with lagged feedbacks from the citizens), introduces the citizens as an indirectly active participant toward the governing process. Compared to surveillance where the government may use technology to control citizens, GEM uses technology to provide governmental services for those who need and what they need. The feedback generated could motivate the municipality to rapidly re-direct or re-allocate its budget. Even before the end of the fiscal year (or before any census is conducted), the government will be provided a detailed, timely, and nuanced view of its region.

Serving the Armchair Auditors

GEM is not necessarily an exclusive methodology for the government. Not-for-profit organizations and citizens could also conduct armchair auditing by GEM methods. Armchair auditing was first proposed by David Cameron, at the time the Prime Minister of the United Kingdom (Cameron, 2009) who imagined the effect that an army of armchair auditors (citizens with open data[7]) would have on government expense reports. For example, the National Institute for Educational Studies and Research of Brazil had established the National Basic Education Assessment System (SAEB) to provide the Basic Education Development Index (IDEB)[8] and general public assessment instruments. The purpose of the system is to make government more transparent and facilitate individual citizens to monitor and analyze data governance actions. In

[7] https://www.fedscoop.com/open-government-data-act-law/
[8] http://portal.inep.gov.br/basic-education-assessments

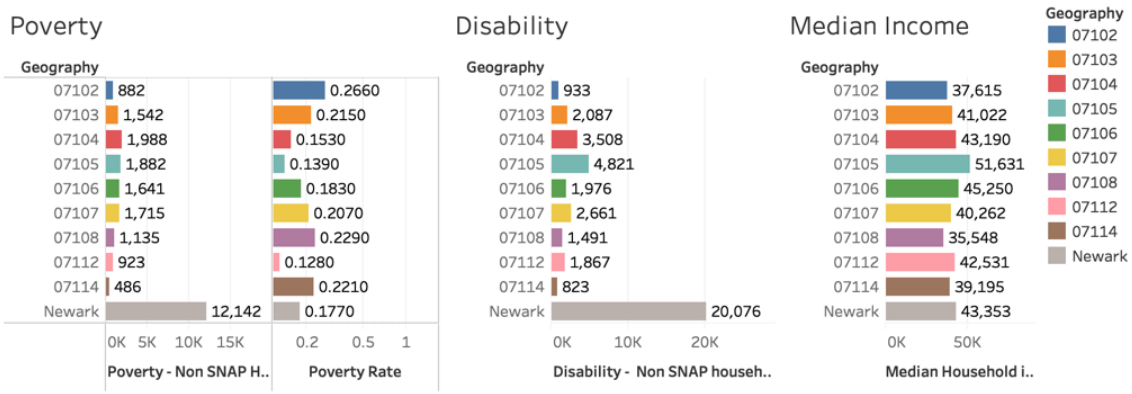
summary, such methodologies could reduce the deadweight loss caused by budget discrepancies, while providing means for citizens to both, directly and indirectly, guide the government.

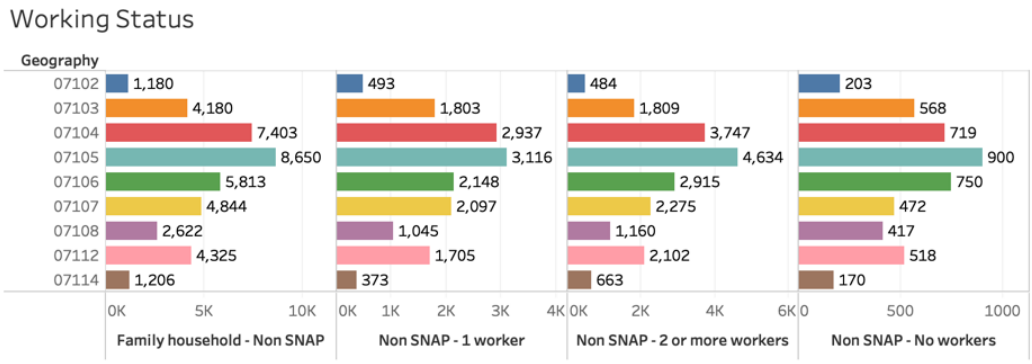
Hypothetical Case Study 1: Visualization on SNAP Program

SNAP, the Supplemental Nutrition Assistance Program, formerly known as the food stamps program, is the federal nutrition program administered by the United States Department of Agriculture, under the Food and Nutrition Service (FNS). According to FNS report, in Fiscal Year 2018, there were 40,424,539 participating individuals and the total cost of the SNAP program was $60,887,714,177 (Food and Nutrition Service, 2019). Also, estimations of fraud reach as high as $216 million. In this section, exogenous data (demographic, economic, and neighborhood) is used to generate methodologies to identify the hunger issue related to SNAP distribution and suggest targeted actions.

Demographic Statistics

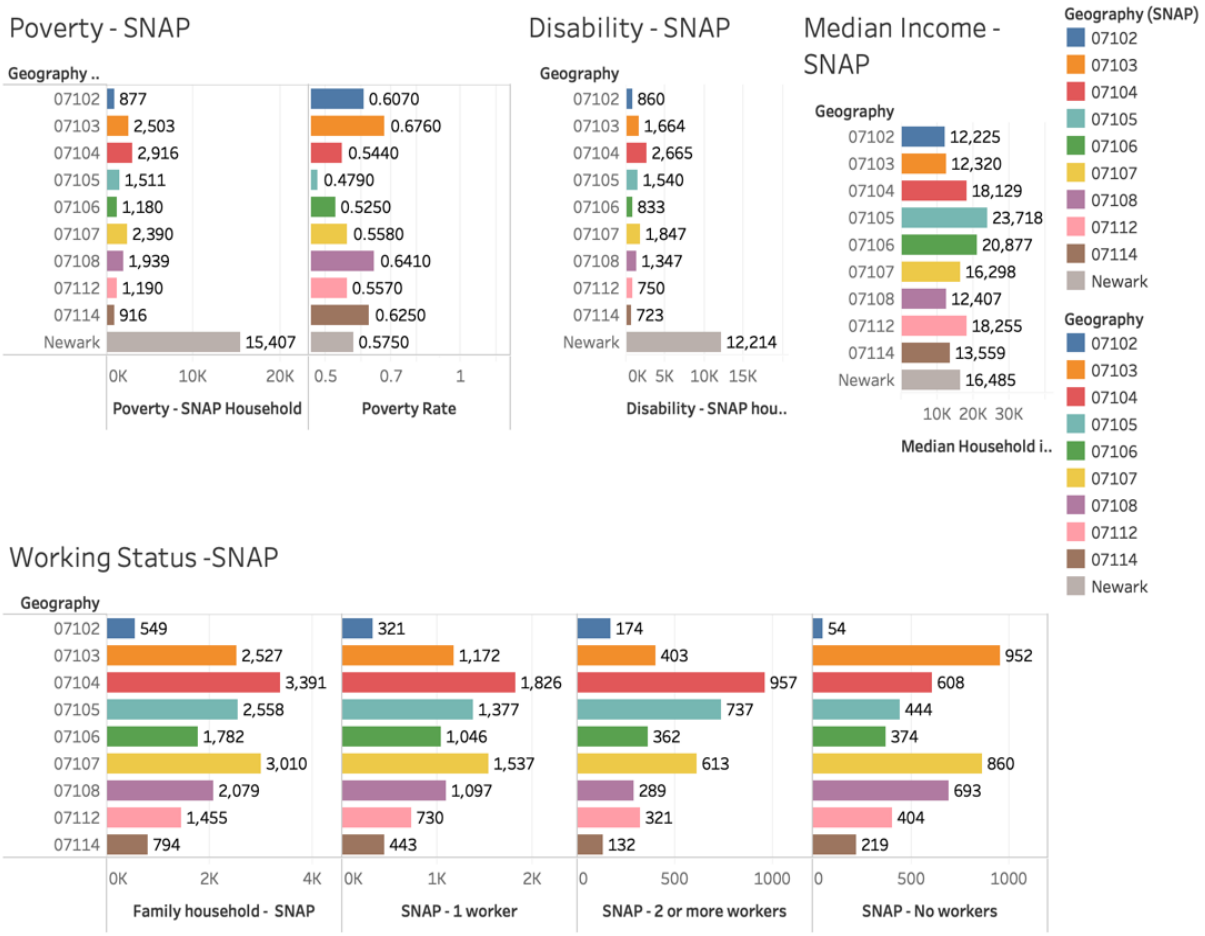
Traditionally, the demographics, economics, neighborhood data are measured periodically in a batch process with clear latency issues. These factors cause current socioeconomics measurements to neither be timely nor accurate. For the fiscal year of 2017, 34,967 out of 69,765 children under 18 were not SNAP recipients in Newark (U.S. Census Bureau, 2017). The challenge is determining whether any of these 34,967 children have been overlooked but deserves SNAP assistance. Combining some additional attributes (i.e. poverty household, poverty rate, electric consumption of the household, notes from teachers, social media utterances, a household with disability members, median household income, and working status of household data) the result shows that among the Non-SNAP individuals or households, there are 12,142 living under poverty, and 20,076 households with a disability. Figure 3 visualizes the basic demographic information of the Non- SNAP family organized by zip code where **Error! Reference source not found.**Figure 4 lists basic demographic information of the SNAP family in the City of Newark. Unsurprisingly, the poverty rate of the SNAP population as high as 67.6%, and the average poverty rate of Newark is 57.5%.





- 07102: The highest poverty rate of 26.6% among all the regions in the city of Newark.
- 07105: Relatively high economic status within Newark; however, records the highest disability population without SNAP support.
- Difference between the highest and lowest median household income in Newark is $16,083, which indicates income inequality.
- 07102 & 07108: At least 15% of households who are unemployed.

Figure 3: Basic demographic information of Non- SNAP Family in Newark by zip code



- 07105: The lowest SNAP recipients' poverty rate at 47.9% while the overall poverty rate of Newark is 17.7%.
- Total Non- SNAP disability population is almost twice of the disability population of SNAP recipients in the city of Newark, which indicates that the population is underserved.
- Median household income of SNAP recipients is only 48.02% compared to Non- SNAP population.
- The unemployment rate for the SNAP recipient group is higher than the Non-SNAP group (37.67% in Zip Code 07103).

Figure 4: Basic demographic information of SNAP Family in Newark by zip codes

Economic Status

Based on the retailer registration information from the United States Department of Agriculture SNAP dataset (U.S. Department of Agriculture, 2017), SNAP retailers are identified and represented in a heat map (see Figure 5) that reflects household effective income. Using the latitude and longitude of these retailers, their location can be identified. Currently, the number of retailers seem appropriate for the local population. In Figure 6, it is found that the effective

household income for eight out of nine zip code areas is lower than $37,000. From the data, effective household income is drastically lower in the city of Newark than that of the surrounding cities. This dataset also reveals the fact that Newark has more demand for SNAP services, based on the location density of SNAP retailers within the city. However, it would be interesting to find out whether the SNAP retailer zip code density or coverage matches that of the total impoverished population or SNAP recipient need. Ideally, there should be more SNAP retailers located in areas where there are many SNAP recipients or high levels of poverty.

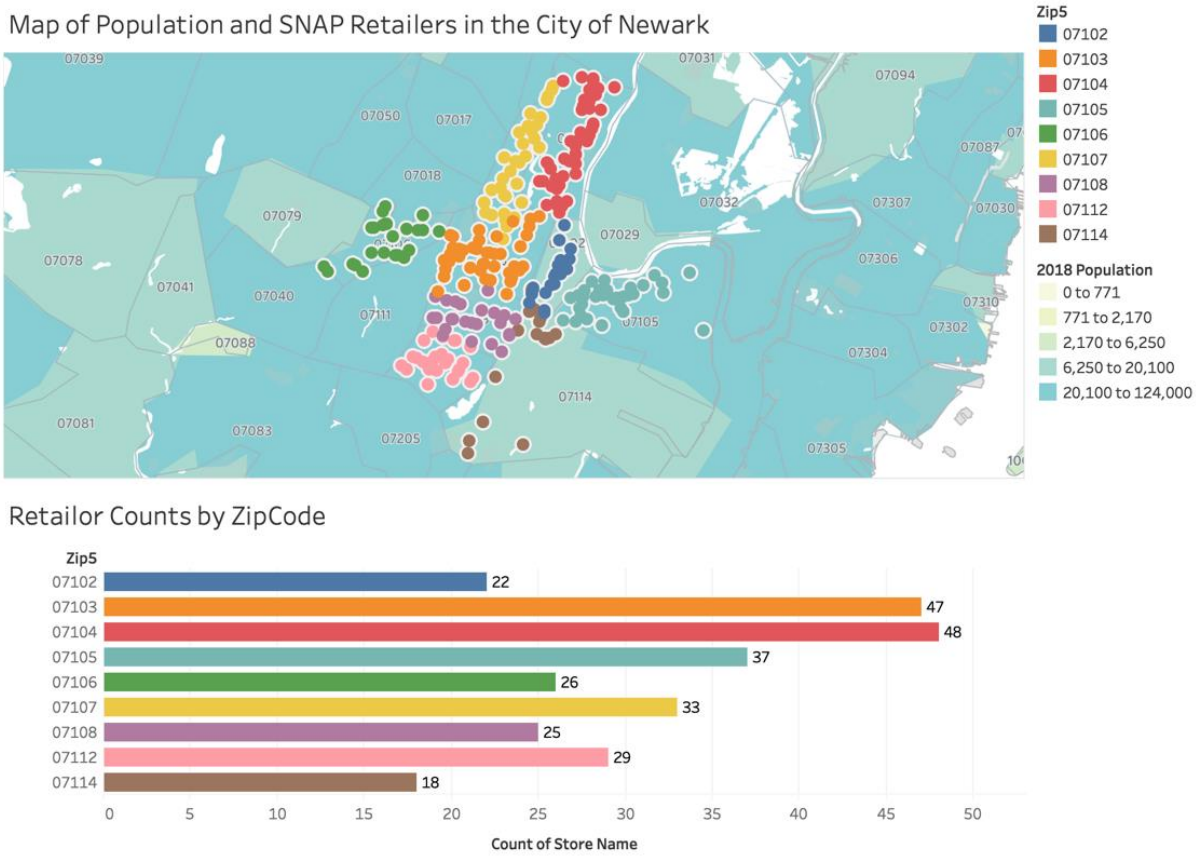


Figure 5: Heat Map of Population and SNAP retailers in the City of Newark

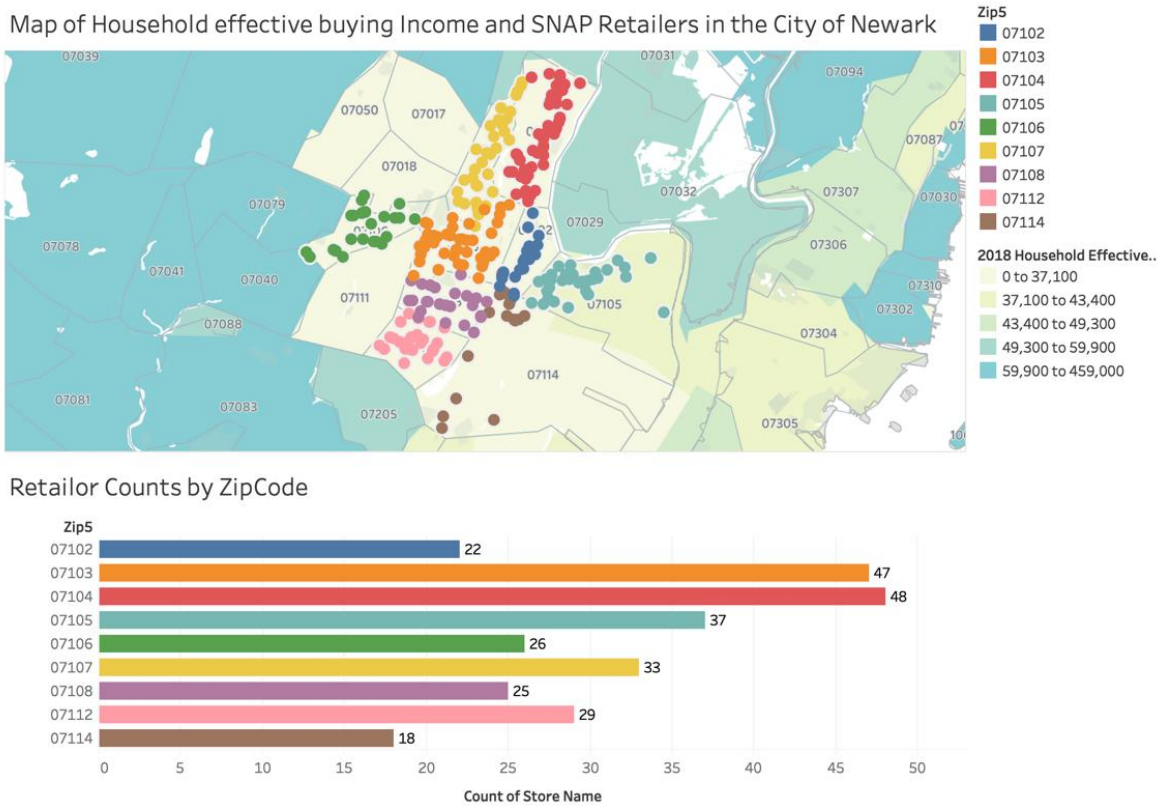


Figure 6: Heat Map of Household Effective buying income and SNAP retailers in the City of Newark

Table 1: SNAP Retailer Coverage

Zip Code	**Total Population**	**SNAP Retailer Count**	**Coverage**
07102	12,986	22	590.272727
07103	32,610	47	693.829787
07104	51,398	48	1070.79167
07105	53,323	37	1441.16216
07106	33,140	26	1274.61538
07107	37,797	33	1145.36364
07108	21,993	25	879.72
07112	26,016	29	897.103448
07114	13,698	18	761

The local SNAP retailer coverage should be divided based on the distribution of the population. However, there exists a coverage difference in Newark (Table 1). The coverage map is presented in Figure 7, where the smaller radius indicates the better coverage of the SNAP service.

After identifying the need for the service and mapping the location of the service provider, the next step should be optimizing the potential service.

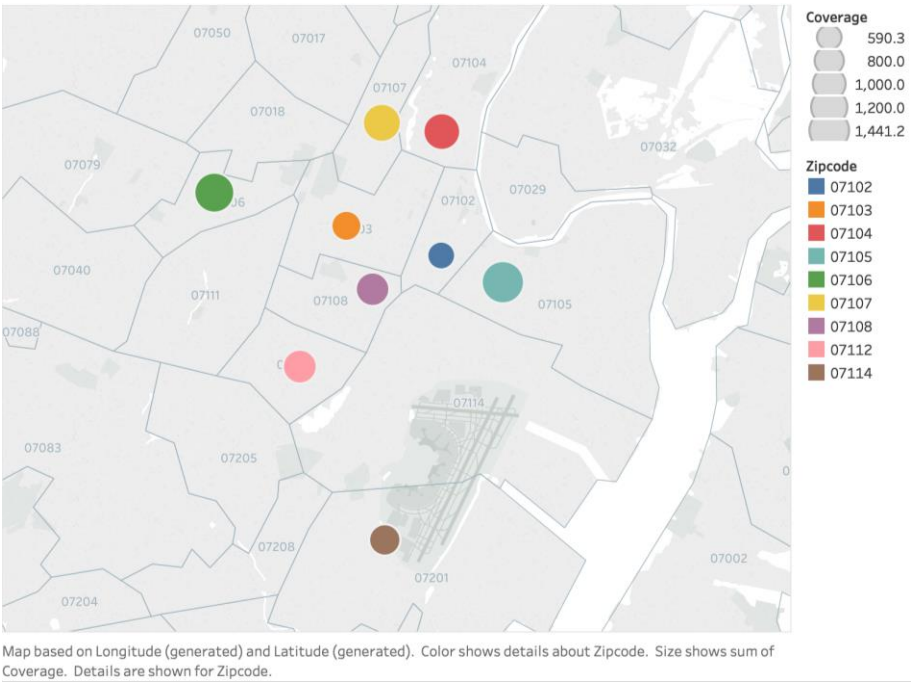


Figure 7: SNAP Retailer Coverage

Possible governmental targeted action

After identifying the demand for the service, targeted actions and feedback toward the satisfaction of these demands should be made in a timely manner. In order to provide proper SNAP services, there should be at least one SNAP retailer in the radius of 5 miles to the SNAP recipients. The distribution could be better estimated when retailer selling data is used, consumer purchase data, good supplier data, Electric Benefit Transfer (EBT) card information, and consumer dietary habit data, etc. Furthermore, matching these transactions with different exogenous data would hopefully be able to prevent potentially fraudulent activities. Utilizing the Distributed Ledger Technologies (DLT or based on blockchain technology) could be an efficient way to manage privacy concerns of the data while reducing the additional need for a trusted authority. Abnormal activities would trigger alerts leading to targeted action. For instance, if the system shows that SNAP Household *B* hasn't used its EBT card for two months, and this household consists of a single mother with two children under 18 and the mother is in the hospital for surgery, the system would flag this particular Family Block and the action agent would be notified. Agents would then

provide GEM targeted assistance to the family such as sending food and assistance directly to the children, instead of sending the monthly support to the EBT card.

Accordingly, the household will receive diet recommendations from the U.S. Department of Agriculture (USDA) to solve health problems such as diabetes, obesity, and hypertension, etc. Healthcare is another important part of the social welfare.

Toward better Solution for Social Pathologies

The introduction of dynamic governance by GEM strengthens the capability of a municipal government to identify and act toward remediation of social pathologies. Third parties such as advertisers continuously monitor and collect data about their subjects of interest to provide targeted advertisement. For instance, one day you adopt a lovely puppy, and the following day your browser will be flooded with advertisements of items your dog will need. Zuboff (2019) describes a plethora of such utilization of behavioral surplus by multiple digital players. This technology can just as well be used to improve public welfare. This entails two main processes: the first identifies potential social pathologies at the community level and then secondly provides targeted actions to mitigate the effects of these social pathologies.

Identification using analysis of exogenous data will help individuals or families who need support and who are currently out of reach from the government. For example, the National Center for Health Research (NCHR) reports that domestic violence often repeats while not being reported[9]. Based on identifying patterns of domestic violence, GEM could flag potential victims of domestic violence and follow up with targeted support to those to escape from the loop.[10] In conclusion, agents (e.g. government, non-profit organizations) could benefit from GEM to determine the most effective and efficient targeted action to improve community welfare. In the following section, we will discuss the identification and targeted action by GEM processes that address these social pathologies.

[9] http://www.center4research.org/cycle-domestic-violence/

[10] The cycle of domestic violence is composed of three phases: tension building phase, abusive incident, honeymoon phase. The temporary mitigation of an abusive relationship (e.g. apologies, gift) during the honeymoon phase makes the victim to not report or ask help to avoid future domestic violence. Personal shame or economic dependence aggravates this cycle.

Social Pathology Identification

In order to identify social pathologies, many approaches may be used. For example, a similar approach to targeted advertising such as geo-targeting may be used. The system identifies patterns shared by people with similar attributes (i.e. income, residence status, education level, etc.). Next, GEM determines the normal pattern of the FB. As a result, the system will calculate how much each FB deviates from the normal pattern. For instance, when it is established that each house uses on average 80 therms of gas per month, using gas under average while earning a low amount of income could be a potential indicator of child hunger. Identification processes differ from branding people (e.g. stigma) since it is used to identify individuals who need help from the government.

Such behavior deviating from the social norm is called deviance (Macionis and Gerber, 2010). Deviance has three actors: 1) the individuals (or groups) who are the cause of the deviance, 2) the others who are the subject to be influenced by the deviance, and 3) the government who affects society to reduce deviance. Centralized control by the bureaucracy, or the decentralized control by the market, makes the deviance to be costly and consequently reduces social pathologies (Gottfredson, 1990). Surveillance and government action are examples where the centralized evaluation of FBs may be used to reduce adverse behavior.

During the identification process, privacy may be improved by a Privacy-preserving Blockchain Database (PPB) approach (Brown-Liburd et al., 2019). PPB continuously develops a suspicion function based on relevant exogenous data. After the suspicion function is developed, homomorphic data encryption is utilized to calculate the suspicion score. Homomorphic encryption allows calculations on encrypted input. Third parties who provide the information encrypt the data and individual identifiers (name, social security number, and other unique identifiers) not to reveal any personal information. If exceptions are found these will be sent to the action agents (government, or non-profit organizations) to perform remedial activities. The action agent will be able to decrypt selective profiles of the individuals, but the data will be protected over its path and in storage databases. (Figure 8). The encryption algorithm will be tailored to the particular social pathology examination blocking access to all but the specific relevant action agent.

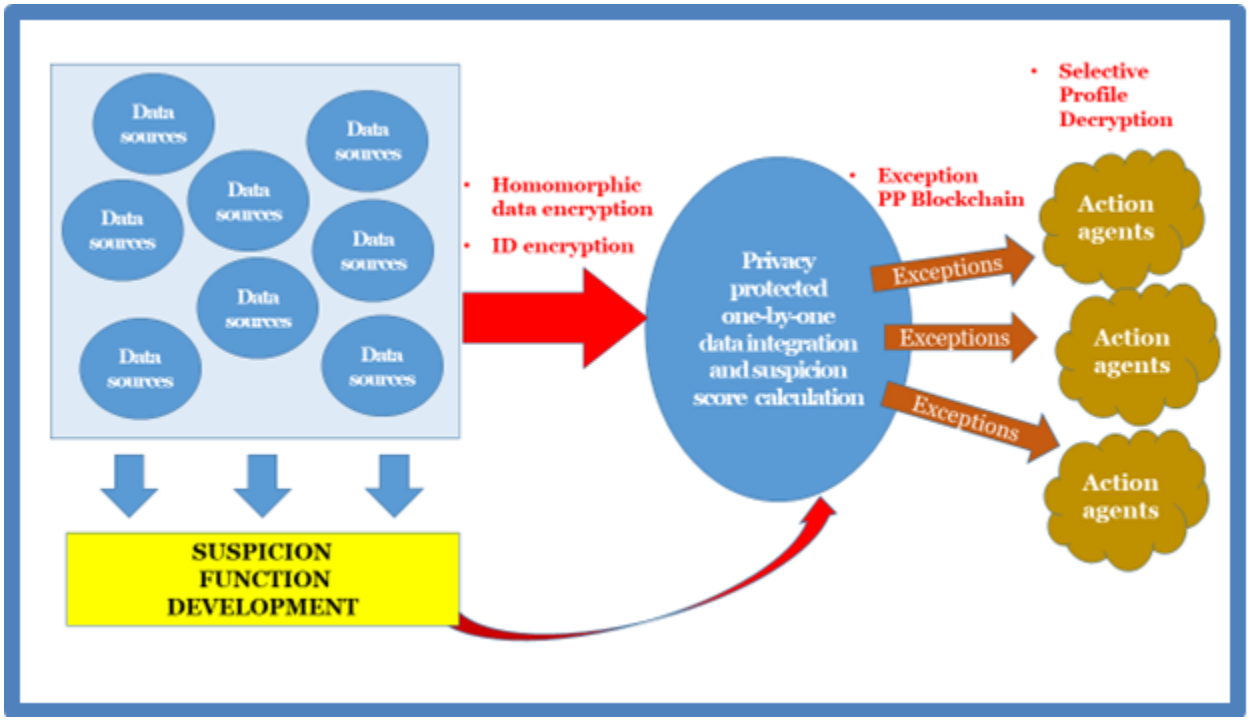


Figure 8: *Data capture, analysis, and distribution (Brown-Liburd et al, 2019)*

Targeted Action towards Social Pathologies

After the action agent is notified about the exceptions, GEM assists the action agents to provide the remedial activity. Using similar technologies to the ones in the identification process, agents will be informed of what remedial assistance the individual or FB needs. For instance, when a spouse who is suspected to be a victim of domestic violence, the information would also be provided about the lack of economic independence of the victim. Not only by providing insights that may preventatively effect actions that would secure the physical safety of the victim, but the system could potentially guide the agent to provide job education opportunity to the victim. However, there would be cases where the one who is suffering is the actual one who is causing the social pathology (e.g. drug addiction). In such a case, the addicted individual could be assisted by finding the attributes which are triggering this drug addiction. The socioeconomic attributes of the individual being assisted would be provided to the action agents which could establish a better rehabilitation plan. Furthermore, feedback would be provided through monitoring the outcome of executed actions. Based on this feedback, the action agent could adaptively change the imposed actions for better performance.

Hypothetical Case Study 2: Revealing Demands for Opioid-related drugs (Analysis on Google Trends and Bitcoin)

The Centers for Disease Control and Prevention (CDC) estimates that more than 72,000 people were killed by drug overdose in the United States in 2017[11]. Recently, a higher number of people are becoming addicted to opioid-related drugs, leading to what is known as opioid epidemics (crisis). Law enforcement has been devoted to fighting against the opioid epidemics by focusing on the demand side (i.e. buyers). Consequently, most of our understanding of the severity of the addictions are learned through the death rate or hospital crisis reports caused (suspected) by specific opioids. To better control opioid addiction, municipalities could monitor the drug market by using a variety of exogenous data sources. In the following section, we demonstrate an example using exogenous data to monitor the demand for opioid-related drugs by using Google Trend data and Bitcoin price.

Google Trend[12] data provides an index of certain Google Search keywords by region. Although drug trades are usually conducted in the dark market located in the Dark web which is not searchable on the surface web (e.g. Google Search), buyers search the URL address (Dark web) of the drug market on the surface web beforehand. Thus, Google Trends could reflect some of the demand for opioid-related drugs. One hundred and one keywords are collected including the street names of opioid-related drugs (see Appendix 2). The daily trend results for each keyword are averaged and aggregated at a monthly level limited to New York City. The results are shown in the red graph in Figure 9: Analysis of Demand for Opioid Addiction.

[11] https://www.cdc.gov/drugoverdose/data/analysis.html
[12] https://trends.google.com

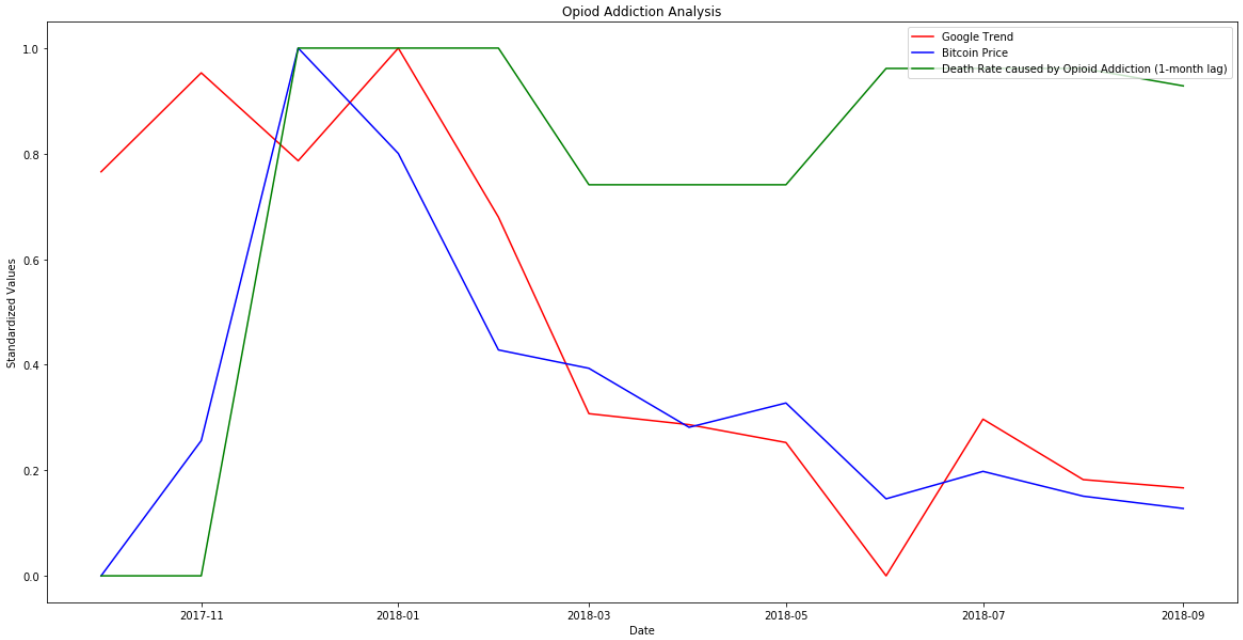


Figure 9: Analysis of Demand for Opioid Addiction

According to law enforcement, drug traffickers find cryptocurrencies preferable for trades due to their anonymity and these trades comprise a significant portion of Bitcoin transactions in some platforms (Mui and Sloan, 2018). By comparing the drug demand proxied by Google Trend and Bitcoin price changes in late-2017 to mid-2018, the correlation between Bitcoin price (blue graph) and drug demand is shown in Figure 9[13]. The results could be further validated by comparing the drug demand with one month lagged actual (suspected) death caused by opioid addiction (green graph). The graph illustrating actual deaths caused by opioid addictions is based on the quarterly data provided by the New York State Department[14].

Note that the process given in this section is a brief illustration of future research. However, by monitoring Google Trend Data with more granularity (i.e. zip codes), the municipality could identify the real-time demand of opioid-related drugs in specific regions. Further, the government could better monitor any suspicious activities related to opioids (e.g. overdosed prescription written by doctors). In sum, the case study shows that exogenous data could be utilized to efficiently monitor the opioid market. What follows are suggestions in **Error! Reference source not found.** for additional research and applications of a GEM-MED approach:

[13] Historical Bitcoin price data was collected from: https://www.investing.com/crypto/bitcoin/historical-data
[14] https://www.health.ny.gov/statistics/opioid/data/pdf/nys_jan19.pdf

Table 2: Additional areas for GEM-MED research and applications

Social Issue	Suggested data sources	Suggested analytics
Suicide	• Social media posts • Google Search data • Anonymous call centers • Economic trends data • GPS data	• Keyword analysis • Google Search analysis • GPS tracking • Unusual spending • Following up on call center leads
Spousal Abuse	• Social media posts • Google Search data • Anonymous call centers • Economic trends data • Street/storefront/traffic videos	• Keyword analysis • Google Search Analysis • Following up on call center comments/leads • Flagging videos showing an injured person
Child Abuse	• Social media posts • Google Search data • Anonymous call centers • Economic trends data • GPS data • School/storefront/street cams	• Keyword analysis • Google Search Analysis • Following up on call center comments/leads • Flagging videos that show an injured child
Gun Violence	• Google Search • Dark web gun sales • State registry (gun owners) • Social media (gun owners) • Metal detectors • Call centers • Street/school/church cams/metal detectors	• Keyword analysis • Matching different data sources to gun owner data • Searching the dark web for gun sales and matching to ISPs • Automatic flagging of suspicious videos and metal detector reports • Actively promote call centers for anonymous reporting

Conclusion

Past research discusses how various family variables influence the future of the children (Shaw & McKay 1932, Gove & Crutchfield, 1982). However, very different from the past, due to technological advances and the massive amounts of rich data being collected, a broader set of socioeconomic measures can be measured in a timely and relevant manner. This methodology may introduce a new dynamic within the municipal government decision-making process since it potentially provides a better understanding of their communities. Some argue that certain interest groups abusively use this technology to take control (e.g. surveillance) or make profits of others (surveillance capitalism) (Zuboff, 2015). Comparatively, the goal of GEM is to benefit society and

to have a better future for children by helping the family and people who need support, not punishing and imposing control to society. GEM represents technology and data used for the public good and not commercial interests. Moreover, instead of collecting and disseminating information as exclusive property for those groups with power, it should be made generic with privacy-preserving functions to enhance transparency and accountability of municipal government actions. In sum, GEM can serve the community for those disadvantaged groups and those suffering from social pathologies. A better future for children can result from improved data usage methodologies when the technology has been used for a better purpose.

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Appendix 1: The Exogenous Data Sources of the City of Newark

Dataset Name	Description	URL
Snowplow Tracks	GPS locations of snowplows	http://data.ci.newark.nj.us/dataset/snow-plow-tracks
Abandoned Properties	Abandoned Properties in Newark	http://data.ci.newark.nj.us/dataset/abandoned-properties
Newark Election Districts	Newark Election Districts	http://data.ci.newark.nj.us/dataset/newark-election-districts
Newark 4311	Newark 4311 Data	http://data.ci.newark.nj.us/dataset/newark-4311
Newark Code Enforcement	Newark Code Enforcement Data	http://data.ci.newark.nj.us/dataset/code-enforcement
Health and Community Wellness Documents	Health and Community Wellness Document(birth)	http://data.ci.newark.nj.us/dataset/dhcw-docs
Newark City Documents	City Documents	http://data.ci.newark.nj.us/dataset/city-forms
Water and Sewer Utility	Water and Sewer Utility Documents	http://data.ci.newark.nj.us/dataset/wsu-documents
Newark MOD 4	Newark Mod4 Property information	http://data.ci.newark.nj.us/dataset/newark-mod-4
Newark Tax Maps	Newark Tax Maps	http://data.ci.newark.nj.us/dataset/newark-tax-maps
Newark Parcel Survey	Newark South Ward Parcel Survey Shapefile	http://data.ci.newark.nj.us/dataset/newark-parcel-survey
Business Licenses	Business Licenses	http://data.ci.newark.nj.us/dataset/business-licenses
Newark Schools	Newark Schools Data	http://data.ci.newark.nj.us/dataset/newark-schools
Certificate of Occupancies	Certificate of Occupancies issued in Newark	http://data.ci.newark.nj.us/dataset/certificate-of-occupancy
Adopt A Lot	Urban Agriculture Adopt-A-Lot	http://data.ci.newark.nj.us/dataset/adopt-a-lot

Newark Jobs	Newark Jobs Data	http://data.ci.newark.nj.us/dataset/newark-jobs
Newark Zoning	Newark Zoning Layer Adopted in 2015	http://data.ci.newark.nj.us/dataset/zoning
Traffic and Signals Permits	Permits issued by Traffic and Signals	http://data.ci.newark.nj.us/dataset/trafficandsignalspermits
Land Cover	Newark Land Cover GIS	http://data.ci.newark.nj.us/dataset/land-cover
Newark Public Libraries	Newark Public Libraries	http://data.ci.newark.nj.us/dataset/newark-public-libraries
Newark Waterways	Newark Waterways Data	http://data.ci.newark.nj.us/dataset/newark-water-ways
Newark Public Buildings & Facilities	Newark Public Buildings & Facilities	http://data.ci.newark.nj.us/dataset/newark-public-buildings-facilities
Newark Parks	Newark Parks	http://data.ci.newark.nj.us/dataset/newark-parks
Newark Neighborhoods	Newark Neighborhoods (pre-super and super)	http://data.ci.newark.nj.us/dataset/newark-neighborhoods
NHA Projects	Newark Housing Authority (NHA) Projects	http://data.ci.newark.nj.us/dataset/nha-projects
Newark Hospitals	Newark Hospitals	http://data.ci.newark.nj.us/dataset/newark-hospitals
Fire Hydrants	Fire Hydrants	http://data.ci.newark.nj.us/dataset/fire-hydrants
Newark Streets	Newark Street Center Lines	http://data.ci.newark.nj.us/dataset/newark-streets
Taxes Paid 2014	Taxes Paid 2014	http://data.ci.newark.nj.us/dataset/taxes-paid-2014
Newark ZIP Codes Polygon	GeoJSON file for Newark ZIP codes	http://data.ci.newark.nj.us/dataset/newark-zip-codes-polygon

Appendix 2: Street names for opioid-related drugs[15]

Opioid, Codeine, Captain Cody, Doors and fours, Loads, Cody, Pancakes and syrup, Schoolboy, Purple drank, Little C, Fentanyl, Apache, TNT, Tango and Cash, Goodfella, Jackpot, China girl, China white, Friend, Dance fever, Murder 8, Percopop, King Ivory, He-Man, Great Bear, Hydrocodone, Fluff, Hydro, V-itamin, Vic, Vik, Watson-387, Hydromorphone, Dillies, Footballs, D, Smack, Juice, Meperidine:, Demmies, Pain killer, Dust, Methadone, Amidone, Fizzies, Maria, Pastora, Wafer, Chocolate chip cookies, Morphine, Miss Emma, M, White stuff, Monkey, Dreamer, First Line, God's Drug, Mister Blue, Morf, Morpho, Vitamin M, White Stuff, Unkie, Emsel, Hows, M.S., Oxycodone, Oxycet, Oxycotton, Oxy, O.C., Percs, Hillbilly Heroin, Cotton, Ox, Pills, Kicker, Roxy, Oxymorphone, Biscuits, Stop signs, Mrs. O, Bomb, Blue heaven, Octagons, Blues, Percocet, Bananas, 512s, Blueberries, Blue, Tires, Wheels, Percs, Rims, M-30s, Kickers, Hillbilly heroin, Greenies, Ercs, Buttons

[15] The list of keywords were find from the following websites: 1) https://www.addictioncenter.com/drugs/drug-street-names/ 2) https://www.nihlibrary.nih.gov/resources/subject-guides/opioids/street-commercial-names