

## MERC PhD Project Proposal 2022/2023

### Title of the research project:

The Iron pipeline: Data driven detection of illegal guns in New York City

### Keywords (up to five)

Dynamical Systems, Human Behavior, Network Science, and Policy

### Supervisors (at least two from two different areas):

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### Project description (max 5000 characters)

According to the report prepared by Nicholas Suplina (Senior Advisor and Special Counsel for the Office of the Attorney General of the State of New York), Lacey Keller (Director of Research Analytics), and Meredith McCarron (Data Scientist), New York law enforcement agencies recovered 52,915 firearms between 2010 and 2015 in New York City (NYC) alone, 74% of which originated from outside New York State. These smuggled firearms mainly came from states south of New York, and were trafficked on Route 95, which gained the name of "Iron pipeline" (<https://targettrafficking.ag.ny.gov/#part2>).

This project brings forward state-of-the-art data science techniques to elucidate the dynamics of illegal gun trafficking in NYC. The proposed research will help answer key questions of value to public safety, such as: How many criminal organizations are involved in gun trafficking? Are there specific venues that most trades take place in? How do these firearms cross the city's borders?

What do law enforcement officials see as barriers to enforcement of laws to keep illegal guns off city streets? Answering these questions will provide law enforcement and government officials with critical knowledge to disrupt the illegal gun circulation in NYC and dismantle its working infrastructure, thereby reducing gun-related violence and harm. Such knowledge will, in fact, result into a graphical interface that could be used by law enforcement officers to apprehend in real-time routes of higher risk for illegal gun trafficking and explore what-if scenarios.

The study will unfold along multiple research steps involving analysis, diagnostics, and modeling, offering a highly interdisciplinary training opportunity for the student. First, we will explore the dataset of seizures through visualization to assess patterns that could inform quantitative analyses. The project will revolve around a spatiotemporal dataset compiled by the New York Police Department (NYPD) on stop and frisk events, from 2003 to 2021 on the precinct level; such events often resulted in seizures of firearms. We will also work with the NYPD and John Jay College of Criminal Justice to acquire more data as a function of the needs we will identify. Next, we will examine the temporal structure of the seizures in terms of seasonality and trends, applying techniques from time series analysis, such as recurrence quantification analysis and complexity measures (Marwan et al 2007, Crutchfield & Young 1989). Following these analyses, we will explore spatial patterns through linear and nonlinear analyses (Porfiri & Ruiz Marín 2020) to understand how seizures are distributed throughout NYC, including border precincts that should correspond to the influx nodes of illegal firearms). Next, we will address the inference problem of determining the main pathway of illegal gun movements coming into the city from sources both within the state and from other states. Such a diagnostics challenge will be tackled in the framework of network theory, treating each precinct as a node so that a link between any pair of nodes describes a likely path of gun movement. Last, we will integrate police enforcement data (such as precinct staffing, stop and frisking policies, and patrol patterns) into the network representation to create a spatiotemporal model that could relate police actions to successful gun seizures. The model will clarify if and how illegal gun traffic evolves in time as a function of police actions. Such a model can then be adapted for field use by law enforcement using interactive software, a project for which the NYPD has expressed enormous enthusiasm.

### Relevance to the MERC PhD Program (max 2000 characters)

Developing quantitative methods to identify the working mechanisms of illegal firearm trade is a key challenge for the scientific community, and its potential contribution towards decreasing firearm injuries in NYC is of great importance. Achieving this goal requires a truly interdisciplinary effort that merges network science, information theory, data analysis, policy analysis and game theory. Therefore, this projects ideally fits the spirit of the MERC PhD program, with respect to its criteria of excellence, interdisciplinary nature, and transformative potential.

Methodologically, this project will represent a unique opportunity to enhance the skills of MERC students in statistical non-parametric modeling and to learn inference tools of complex systems from observational data. The students will have the opportunity to learn mathematical and statistical tools that are at the frontier of knowledge, and receive guidance from two supervisors from complementary academic fields in the US. Along with theory, the students will be trained in data collection, including a rigorous exploration of NYC's extensive open data compendium, and public policy. By working on concrete datasets, the students will have the opportunity to appreciate how the concepts and the scientific approach learned at the MERC PhD school translate to the solution of real-world complex problems.

## Key references

- New York State Office of the Attorney General. (n.d.). Targeting Trafficking. Retrieved February 22, 2023, from <https://targettrafficking.ag.ny.gov/#part2>
- New York City Police Department. (n.d.). Stop, question and frisk report data. Retrieved from <https://www.nyc.gov/site/nypd/stats/reports-analysis/stopfrisk.page>
- Marwan, N., Romano, M. C., Thiel, M., & Kurths, J. (2007). Recurrence plots for the analysis of complex systems. *Physics Reports*, 438(5-6), 237-329.
- Crutchfield, J. P., & Young, K. (1989). Inferring statistical complexity. *Physical Review Letters*, 63(2), 105.
- Porfiri, M., & Ruiz Marín, M. (2020). An information-theoretic approach to study spatial dependencies in small datasets. *Proceedings of the Royal Society A*, 476(2242), 20200113.

## Joint supervision arrangements

The supervisors are long-term collaborators with a track record of joint research in complex systems and public health, who are excited about collaboration and discuss science on a regular basis. As such, students will be part of a vibrant team, where discussions continuously happen in an organic and natural manner. Hence, the frequency of meetings will depend on the stage of the research carried out by the student and on the very need they will have. We expect that there will be periods when meeting twice per month with the all group will be sufficient (for instance, when the student is immersing themselves in a particular methodology), and other periods when one-on-one meetings with either of the supervisors would happen weekly or more often, for example, when dealing with the development of new methods to infer causality from data.

## Location and length of the study period abroad (min 12 months)

The New York University (NYU) Tandon School of Engineering is the engineering and applied sciences school of NYU. Tandon is the second oldest private engineering and technology school in the United States. Located in the Brooklyn Tech Triangle, ten minutes walking to the Brooklyn Bridge and connected with subway to NYU or any of the other NYU schools in the City. Prof. Porfiri is an Institute Professor (the highest distinction at NYU Tandon), with tenured appointments in Biomedical Engineering and Mechanical and Aerospace Engineering. Prof. Porfiri is the Director of the Center for Urban Science and Progress (CUSP), a unique NYU research center created in partnership with New York City for interdisciplinary application of science, technology, engineering, and mathematics in the service of urban communities across the globe. Prof. Porfiri's laboratory, the Dynamical Systems Laboratory (DSL), was founded seventeen years ago with the vision of creating an interdisciplinary space with fundamental research in dynamical systems with clear societal impact. The laboratory is housed between CUSP and the Department of Mechanical Engineering. MERC students joining the project will have office space in the newly renovated CUSP building and access to any of the DSL facilities. At the DSL, they will be fully integrated in any of the lab activities, such as seminars, workshops, focused courses for professional development, and collaborative efforts within and outside the group.

NYU School of Global Public Health (NYU GPH) is an excellent institution for those interested in understanding and improving complex urban systems. With a focus on global public health, the school offers a unique experience that integrates theory, research, and practice to address the most pressing public health issues facing communities around the world. NYU GPH is located in the heart of Manhattan, giving it a vibrant, adventurous and innovative character. Prof. Silver's research

explores the impact of variation in the implementation, adoption and repeal of state and local public health policies, including firearms, on health outcomes.

MERC students joining the project will have office space at CUSP and access to any of the NYU facilities. Ideally, we would like the student to spend 24 months abroad to ensure ample opportunities for training and full integration with the supervisors' research teams

#### [Any other useful information](#)

Using NYC as a living laboratory, CUSP contributes foundational knowledge and novel technologies for increasing our understanding of urban processes and solving complex urban problems, from ensuring the health and wellness of urban populations, to making our cities more accessible and inclusive, to supporting local governments to be more responsive to citizens' needs. CUSP members include faculty and researchers from computer and data science; civil, electrical, biomedical, and mechanical engineering; human-technology design and interaction; applied mathematics and statistics; public health and policy; and the social sciences. CUSP has a large number of ongoing partnerships with city agencies, non-profits, industry, academic organizations, and start-ups that will provide project-based internship opportunities for trainees. These convergent research activities and synergistic connections with NYC put CUSP at the forefront of fundamental and applied research in urban accessibility, a priority of NYC's administration. CUSP runs and Interdisciplinary Doctoral Track, which, like MERC, offers a collaborative environment for excellence in interdisciplinary research. MERC students will be integrated in doctoral activities at CUSP, thereby promoting collaborations with other junior researchers.

As an example of potential synergies, Prof. Porfiri is the lead, principal investigator of the National Science Foundation Project *LEAP-HI: Understanding and Engineering the Ecosystem of Firearms: Prevalence, Safety, and Firearm-Related Harms*, in cooperation with research groups of the University of California, Los Angeles, Northeastern University, and Georgia State University, whose scope is strictly related to this MERC research project. The MERC student will be welcome to be involved in the activities of the project, participate in related meetings, thus further expanding their learning opportunities.

***Please return this form via email by no later than 24<sup>th</sup> February 2023***