Can New Transportation Options Alleviate Spatial Mismatch?

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One Paragraph Summary: The Department of Transportation (DOT) places a strong emphasis on equity and on the use of new transportation investments to foster the socioeconomic mobility of low-income individuals and historically disadvantaged communities. The recent emergence of new transportation modes, rented through smartphones, that provide much of the flexibility of personal vehicle ownership without the fixed costs appear to offer new ways through which the geographic and socioeconomic mobility of America's low-income families could be enhanced. However, relatively little is known about how and to what extent low-income Americans will use these emergent transportation modes. We also know little about the way in which and the degree to which increased geographic mobility would translate into increased socioeconomic mobility. Finally, we lack strong evidence on the kinds of policy supports that could maximize the benefits new transportation modes might provide to low-income users. The research program outlined in this proposal will shed critically needed new light on these questions through well-structured randomized controlled trials that combine rich data on participant mobility, obtained through smartphone-generated GPS traces, with detailed administrative data on income, employment, and other important socioeconomic outcomes. The program will also eventually place in the public domain rich, granular (deidentified) data on the geographic mobility of low-income residents of contemporary American cities and towns that will constitute a valuable resource for the broader research community for years to come.

Introduction: Decades of research by economists and other social scientists have pointed to spatial mismatch as a barrier to employment in American cities. Recent research suggests that spatial mismatch can substantially lengthen spells of unemployment, especially for females, African Americans, and older workers (Andersson et al., 2018). The suburbanization of poverty has also changed the dynamics of spatial mismatch in American cities. Policies seeking to connect lower income and lower skilled workers living in the urban core to jobs may no longer work as these lower income populations move to the suburbs (Frey 2016). As the poor become more geographically dispersed along the urban periphery, the traditional hub and spoke model of most city mass transit systems becomes less useful. Disadvantaged residents need to move from one suburban area to another to pursue employment opportunities, but mass transit systems provide fewer links along the periphery. Some parts of the community are served by a single bus line that runs infrequently, making it challenging to secure employment, particularly third shift jobs or jobs in other suburban neighborhoods.

Now, however, a range of new, smartphone-enabled transportation options are diffusing rapidly through American cities, offering more flexible and convenient methods of transport that do not require incurring the fixed costs of private vehicle ownership. Recent research suggests that use of these new options is currently clustered in the wealthier districts of American cities (Thebault-Spieker, Treveen, and Hecht, 2017), reflecting the reality that the market price points at which these services are currently offered place them out of reach for many of the urban poor. However, targeted public policy interventions could alter this state of affairs. Could subsidized provision of these new transportation options to the poor enable better access to employment, training, and social services? This project seeks to put this question to a series of convincing empirical tests by conducting a series of randomized controlled trials in the Pittsburgh region.

At the same time, the experiments described in this proposal will also address a fundamental limitation in much of the literature that has informed our understanding of spatial mismatch – the paucity of credible *experimental* evidence showing that lower transport costs lead not only to greater geographic mobility but also to higher labor force participation and therefore greater socioeconomic mobility (Brough et al., 2022). Leveraging the emergence of new transportation options in the Pittsburgh region, our project will undertake exactly the kind of randomized control trials that have been largely missing in the prior literature, and it will exploit the rapid diffusion of smartphones among even the urban poor to track the impact of lower transportation costs on geographic mobility and self-reported employment and wages. Additional data collected by our research partner, Allegheny County DHS, will provide an important supplement to self-reported data. These data will also help us infer the impact of lower transportation costs on other social outcomes of interest, including utilization of social services.

Finally, we believe that our proposed combination of standard econometric methods, "app" development, and intensive use of smartphones may inspire other economists to expand their tool kits in similar ways. The wide diffusion of smartphones (even among the urban poor) and the relative ease with which user-friendly "apps" can be created and disseminated have worked together to provide researchers with new, often low-cost platforms through which experimental interventions can be directed and implemented. The same technologies also create important new opportunities for data

collection and measurement, often to a degree of granularity and temporal frequency that would have been unimaginable to earlier generations of empirical researchers. As an example, Figure 1 illustrates the anonymous location trajectory recorded by smartphone of a low-income mother during one day in one of our current pilot studies in Pittsburgh. Different colors represent different times of the day, with the transition from bright yellow to dark red corresponding to the movement from early morning to late night. Such granular location data can enable us to learn a great deal about the movements and transportation choices of low-income populations. Combined with detailed administrative data on employment, income, and the utilization of social services, we can create a rich statistical portrait of how geographic and socioeconomic mobility co-evolve.

Figure 1. An Example of Location Trajectory Recorded by Smartphone of a Low-Income Mom During One Day



Research Questions/Data/Methods: This section of the proposal identifies three distinct research questions we will pursue, along with the key data sources and methods we will use to answer them.

1. *Does access to new transportation options significantly expand the **geographic mobility** of low-income citizens?* As already noted, widespread diffusion of smartphones has enabled a proliferation of new transportation options that offer some of the flexibility of personal vehicles without the fixed costs of vehicle ownership. The current pricing models of the newer transportation options often limit their accessibility to the urban poor. However, smartphone diffusion even among poor families is now quite extensive, raising the possibility that modest subsidies for the new transportation options could allow low-income citizens greater access to them, substantially enhancing their geographic mobility. The GPS capabilities embedded in those smartphones allow for the detailed tracking and measurement of individual mobility patterns (Macha et al., 2021). Our research team has already acquired extensive experience creating and deploying iOS and Android-compatible smartphone apps that gather detailed GPS location data several times per hour, in a way that achieves a good balance between mobility measurement and battery drain on users' phones. Through experience, we have identified robust approaches to mobility measurement that can contend with the noise in GPS data. Working together with CMU's Institutional Review Board, we have developed data anonymization protocols that allow us to analyze these rich data while also protecting the privacy of our participants. We can also make deidentified versions of these data available to the broader research community. Finally, by implementing the best practices of a randomized controlled trial (RCT), we can experimentally manipulate participants' access to particular transportation options and make causal inferences about the impact of this on mobility outcomes. We note some preliminary estimates of the impact of randomly assigned access to Uber rides on various measures of individual mobility in the "Preliminary Research Efforts" section below.

2. *Does access to new transportation options increase the **socioeconomic mobility** of low-income citizens?* The same smartphone apps that collect high-frequency GPS data can also send and receive short surveys that capture aspects of the mobility experience which cannot be measured by GPS data alone. We are already using these tools to measure *self-reported* employment and income. However, we can also utilize the ongoing partnership between Allegheny County Department of Human Services (ACDHS) and CMU to measure the impact of experimentally induced increases in

geographic mobility on the short-and long-term *socioeconomic mobility* of our study participants. ACDHS is a national leader in efforts to link the various administrative data sets generated by the major social assistance programs, local schools, police departments, and courts into a single integrated data warehouse, in which a unique identifier code links individual county residents' data records across data sets. The data warehouse provides comprehensive coverage on the recent income, employment, and social services utilization of the majority of low-income residents of Allegheny County. Birth and school records link adult members of the treatment group to the academic performance of their children in "reporting" school districts. While CMU researchers will not have direct access to sensitive individual-level records, cleared data analysts inside ACDHS can perform statistical analyses on those records and share the results with CMU researchers. This collaboration gives our team an unusual degree of insight into the short- and long-run effects of additional geographic mobility on a broad range of socioeconomic outcomes. In addition to providing us with access to extensive data, ACDHS is a trusted supporter of low-income county residents through its client-facing agencies and through the human service contractors that work under its supervision. Given the role it plays in our community, ACDHS can help publicize our programs and recruit low-income residents to participate in our studies.

3. *How do low-income citizens value different "new" transportation options and option combinations?* Drawing upon a long, rich economic literature modeling consumers' transportation choices (e.g., McFadden, 1974), we will seek to learn how low-income citizens value different "emerging" transportation options. The potential that urban planners and transportation policymakers associate with these newer options is tempered by a lack of extensive data on how much and under what circumstances low-income citizens will choose to utilize them, even when access is substantially subsidized. Some of these options have well known shortcomings, especially in challenging weather conditions. A new phase in our proposed research, undertaken in partnership with the City of Pittsburgh, will provide participants with a menu of options from which they can choose. As Pittsburgh's seasons change, and as a diverse group of low-income citizens is recruited into this study, we may be able to infer important elements of consumers' preferences for these various options. Detailed individual data on transportation choices made from a menu of multiple subsidized emerging transportation options will enable us to address this important set of issues.

Preliminary Research Efforts/ Research Findings

Step 1 -- The "Uber Project": Existing funding from the National Science Foundation, the Hillman Foundation, and CMU's Traffic21 research center has allowed us to begin our research by examining the impact of subsidized access to one smartphone-enabled transportation option: ride-hailing. This project, undertaken in partnership with Uber and Allegheny County DHS, provided us with the resources to develop smartphone apps (compatible with both iOS and Android operating systems) that gather GPS data and provide a platform through which we can send and receive short surveys to participants that enable us to measure aspects of our participants' experience not captured by administrative data sets. While this project is still ongoing, our preliminary findings suggest a causal impact of our treatment on the geographic mobility of our participants that is statistically significant and economically meaningful. The measured impact varies depending on the exact specification (e.g., daily distance traveled, daily distance from home, radius of gyration), but appears to lie in the range of 10-20%. In addition, transit times can be reduced by as much as 70 percent relative to a counterfactual trip using only public transportation. Our preliminary findings on socioeconomic mobility also indicate a positive impact on employment and income. The likelihood of employment for the treatment group increases by 12.4 percentage points in the third quarter after participation in our project begins, and this effect is statistically significant at conventional levels. We also find an increase in quarterly earnings ($730) emerges at the same time, although this is currently measured with much less precision. Survey evidence suggests that participants are using the resources provided to members of our treatment group to expedite their job searches and their commutes to work but are also using these resources to expand access for themselves and their families to other social resources, including health care, parks and recreation, and goods and services purchased outside their neighborhoods. More details about this study are available upon request.

Step 2 -- Guaranteed Mobility for Pittsburgh's Low-Income Residents: This spring, our CMU team will begin a pilot study in cooperation with the City of Pittsburgh's Department of Mobility and Infrastructure, SPIN (a national provider of e-scooter transportation services), the Hillman Foundation, and other local nonprofits. Rather than provide low-income residents with subsidized access to a single smartphone-enabled transportation option, such as Uber, this pilot will provide access to a *menu* of transportation options, including standard mass transit (through monthly transit passes), Pittsburgh's POGOH bike-sharing service, SPIN (which offers access to smartphone-activated electric scooters across the city), and the Zipcar car rental service. Low-income Pittsburgh residents will be recruited into a randomized controlled trial in which the treatment group will get 12 months of generously subsidized access to the full menu of transportation options described above. Members of the demographically equivalent control group will receive gift cards in return for downloading our GPS apps and responding to surveys over the same period. Use of our smartphone apps by members of both groups will allow for precise measurement of the magnitude and nature of any impact of the treatment on geographic mobility. This information will be supplemented with detailed user-specific information on utilization of the transportation options described above. As in Step 1, ongoing cooperation with Allegheny County DHS will allow comprehensive measurement of the impact of treatment on socioeconomic mobility.

This new step in our research program provides a broader and far more generous menu of transportation options to participants than our first study. In principle, participants in the treatment group could have access to total transit resources worth more hundreds of dollars per month for up to one year. More generous, broader support could lead to larger measured increases in geographic and socioeconomic mobility. By offering a diverse group of low-income citizens a broad menu of options, the project can also begin to elicit low-income consumer preferences for these options, contingent on consumer characteristics (gender, age, etc.), environmental factors (weather, temperature, time of day, etc.), and other variables, by observing participants choices. Data obtained directly from the transportation providers ***and*** advances in our ability to directly measure transitions from one transportation mode to another using GPS traces enable us to generate a much more detailed and nuanced statistical portrait of the movement of low-income individuals across our city than was possible in our earlier Uber project. Despite these attractive features, current funding limitations restrict our sample size to a relatively small number of treatment and control participants. In addition, the menu of transportation options in this Guaranteed Mobility study is far from complete, and the geographic focus of the study, limited as it is by the jurisdiction of the City of Pittsburgh, necessarily omits consideration of low-income citizens in Pittsburgh suburbs and adjacent communities. This is a significant omission, because – like cities across the nation – Pittsburgh has seen growing populations of low-income citizens choosing to reside *outside* the urban core, where conventional mass transit service is far less dense than in core neighborhoods. Many of the parts of Allegheny County that have seen the most growth in less skill-intensive jobs are also located outside the urban core, creating a growing need for longer-distance commuting solutions that are not currently part of the menu of the Guaranteed Mobility study.

The Next Step -- Expanding Transportation Options and Sample Size: We are currently seeking substantial funding for an expansion of the project described above with respect to sample size, geographic scope, and transportation options. In order to better capture the impact of subsidized access on geographic and socioeconomic mobility, we seek to recruit at least 400-600 participants to participate in our next set of RCTs. We also seek to expand the geographic scope of our study from the City of Pittsburgh to all of Allegheny County, enabling us to offer new transportation options to residents that are especially poorly served by conventional mass transit. Given this larger geographic scope, we also wish to include additional transportation options that could provide subsidized support for the kinds of longer distance commutes that are increasingly common for low-income workers in our region, even in unfavorable weather conditions. These additional transportation options would include regional micro transit agencies that cooperate with and extend the reach of mass transit, such as RideACTA, more conventional carpools and vanpools that are generously subsidized by the state, such as those supported by the Commute Info program, and new entrants into the ride-hailing industry that offer services on a subscription model and are more focused on the needs and travel patterns of lower-income individuals and families, such as RubyRide. With the support of an NSF Civic Innovation planning grant, we have worked out provisional cooperative relationships with ten separate regional transportation service providers. Unfortunately, we have not yet secured sufficient funding to engage this full network at the desired scale. We look forward to working with other participants in this NBER project to identify nontraditional sources of funding that might provide us with the necessary financial support.

Research Team: PI Lee Branstetter is an expert on the economics of innovation and technology diffusion. His work has been published in leading journals including the *American Economic Review*, the *Quarterly Journal of Economics*, the *RAND Journal of Economics*, the *Review of Economics and Statistics*, and the *Economic Journal*. Professor Branstetter is a research associate of the NBER, and he served as a senior economist on the staff of President Barack Obama's Council of Economic Advisers in 2011-2012. As the Director for the Future of Work Initiative at CMU's Block Center for Technology and Society, an interdisciplinary research center based in Carnegie Mellon's Heinz College, Professor Branstetter also brings to the project strong ties with social service agencies and nonprofits in the Pittsburgh region that regularly interact with the population this project is designed to help. Branstetter is the PI for NSF grant "Driving Low-Income Mothers to Greater Success: The Impact of Ride-hailing on Employment and Income" (SBE- #1851862), $285,080 and for NSF grant "City of Bridges: Using New Transportation Options to Drive Low-Income Mothers to Greater Success in Pittsburgh" (SCC-CIVIC-PG 2043634), $50,000.

Co-PI Beibei Li has extensive experience at leveraging both observational data analytics and experimental analysis in analyzing large-scale individual user behavior and mobility data across online, offline and mobile channels for decision support and user interface design. Her background in computer science and doctoral training in information systems will enable her to provide effective leadership of the technical aspects of this project, including the development of information collection systems and improvement of smartphone aps. As a professor in one of North America's leading professional degree programs in analytics and information systems management, Professor Li has access to a broad away of talented and experienced doctoral and masters students, with strong programming and data analysis skills, ensuring that we can recruit outstanding graduate research assistants for this project. Professor Li's research skills are evidenced by her publication record and by her receipt of the Anna McCandless Career Development Professorship. Li was co-PI on the two NSF grants named above.

Conflict of Interest Statement: Neither PI has any significant financial investment, corporate board seat, consulting arrangement, or any other relationship that might impact the conduct of the research described this proposal. However, we acknowledge that Uber Technologies, a leading ride-hailing company, has supported one of our ongoing randomized controlled trials, described earlier in this proposal, through the provision of a substantial number of free rides to our study participants. The commercial value of this in-kind support is approximately $320,000. This in-kind support has not affected our conduct of the research, nor will it impact the conclusions we derive from our analysis. Nevertheless, we acknowledge this support from Uber Technologies in the interests of full disclosure. We also noted our participation in a new mobility project led by the City of Pittsburgh's Department of Mobility and Infrastructure. SPIN, a national provider of smartphone-enabled e-scooter mobility services, has pledged to contribute $50,000 toward the total cost of this project. In addition, transportation providers POGOH and SPIN have offered to discount their service provision over the life of the study. The market value of these discounts is expected to be $3,000 and $56,000, respectively. Neither PI will receive compensation directly from SPIN, nor will they receive the subsidized services. These provider contributions will not affect the conduct of our research or the conclusions we derive from our analysis. Nevertheless, we acknowledge this in the interests of full disclosure.

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