Transport and urban labour market integration: evidence on travel time and congestion from a mass transit quasi-experimental evaluation and evidence on firms from a randomised control trial in Pakistan

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Grantee Final Report

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Note to readers

This final impact evaluation grantee report has been submitted in partial fulfilment of the requirements of grant DPW1.1053 awarded under Development Priorities Window 1. The report is technically sound, and 3ie is making it available to the public in this final report version as it was received. No further work has been done.

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Summary

A well-integrated urban public transport network contributes to economic growth by reducing transport costs and travel time, facilitating specialization of firms and workers, and decreasing the cost of economic transactions. Yet, despite increasing urbanization, Pakistan's cities suffer from a poorly connected public transport network. In qualitative interviews, employers report that transport for their workers is a problem especially for female workers, who are restricted by cultural norms, harassment and stigma when they travel. This limits individuals' ability to find good job opportunities, and firms ability to hire qualified workers.

To help address these problems, the government of Pakistan has embarked on an ambitious plan to build rail and bus based mass transit systems in large cities including Lahore, Rawalpindi/Islamabad, Faisalabad, Multan and Karachi. Critics have questioned the value for money of such investments. However, the economic and social impact of greater mobility remains unstudied, and these discussions have remained politicized and superficial, due in part to a lack of evidence on the effects of these policies. This study will inform this debate with rigorous quantitative evidence. It will also help to inform specific design features of future urban transport investments and complementary policies.

This 3IE-funded study tests the impact of transport on labor markets and other economic outcomes in Lahore, Pakistan, using experimental and quasi-experimental analysis on microdata from households / jobseekers and employers. The first part of this report discusses Component 1 of the evaluation, which uses a quasi-experimental analysis to quantify the impact of the Lahore Metrobus (mass transit line). The second part of the report discusses Component 2, which uses a randomized control trial to study the impact of a transport to work intervention on men, women, and the differential impact of women's-only transport. The intervention is a pilot door-to-door pick-and-drop service which takes individuals from home to work every day at fixed times on a monthly subscription basis.

In Component 1, we find that access to the new transit line reduced both the time and cost of commuting, with an estimated 30% increase in public transport use in nearby areas and an estimated 35,000 commuters who switched from private modes. The mass transit line attracts a larger proportion of highly educated riders than those who rode public transport before its introduction, suggesting that its high quality and reliability make public transport options acceptable to a broader part of the population. Even though the capital cost of the transit line was substantial, and its fare is subsidized, most riders are willing to pay a substantially higher fare that could make the service financially more sustainable. The following researchers worked on Component 1: Kate Vyborny[1], Hadia Majid[2], and Ammar Malik[3].

In Component 2, preliminary results show that women respond more to offers of transport as compared to men. This includes women who were not searching for jobs at baseline. Additionally, the impact on women's job application rate is greater when they're offered women-only transport compared to mixed-gender transport. The following researchers worked on Component 2: Erica Field[1] and Kate Vyborny[1].

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Abbreviations and Acronyms

BRT	Bus Rapid Transit
PKR	Pakistan Rupees
PCSW	Punjab Commission on the Status of Women

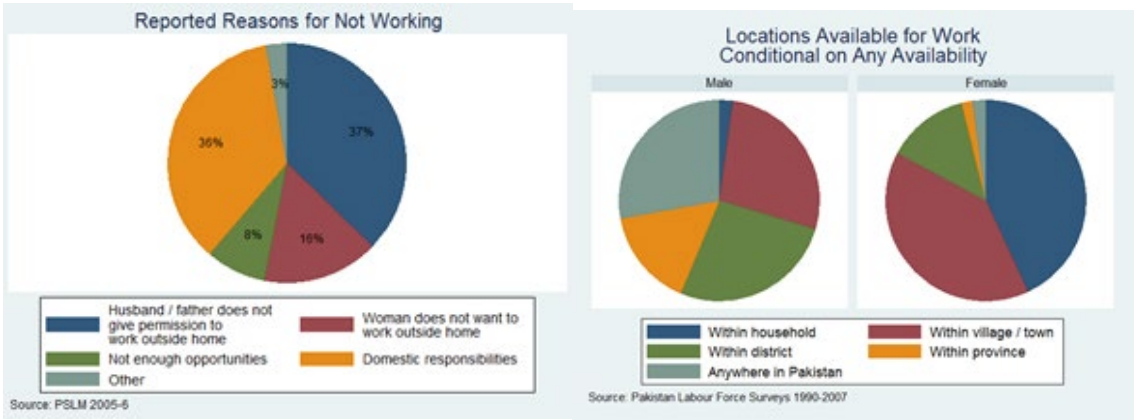
0. Introduction for Components 1 & 2

Urban public transport facilitates specialization of firms and workers. Yet, despite increasing urbanization, most of Pakistan's cities suffer from a poorly connected public transport network. This limits the pool of workers that firms can attract within the city, reducing the benefits of urbanization.

To help address this problem, the government of Pakistan has embarked on urban public transport investments including construction of mass transit lines in all the country's major cities. However, quantitative evidence on the impacts of these investments is limited.

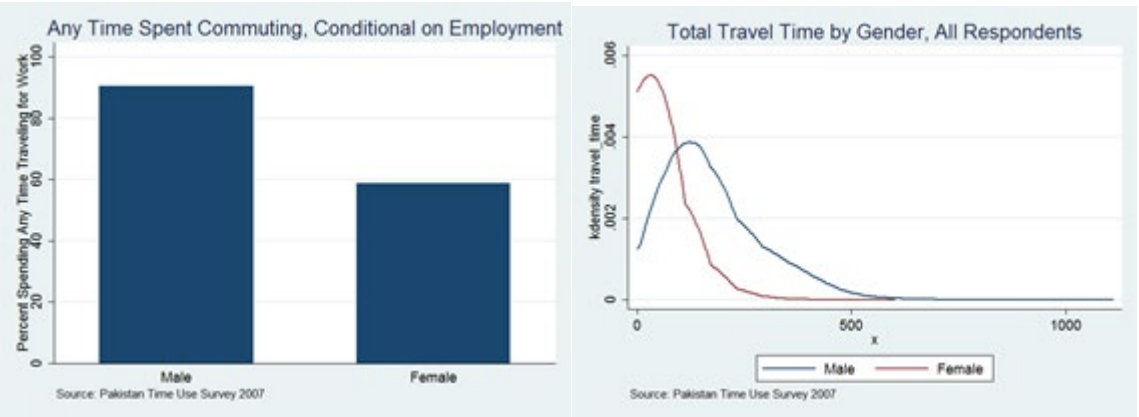
Women are affected differently by transport policies because they face stigma and harassment when traveling on public transport. As a result, few women are willing to ride public transport. Recent analysis by the Asian Development Bank (ADB) has demonstrated the severity of this issue, with 85% of working women surveyed in Karachi reporting harassment on public transport in the last one year, and many reporting switching from public transport to other modes of travel to avoid harassment[4]. These constraints may have a major impact on women's labor market decisions. Figure 1 and Figure 2 demonstrate this: women frequently report their reason for not working is a problem with permission working outside the home; women who do want to work are more limited geographically, and those who do work tend to work closer to home and have shorter commutes.

Figure 1: Women's Physical Mobility and Labor Force Participation



[4]ADB 2015, "Policy Brief: A Safe Public Transportation Environment for Women and Girls;" ADB 2014, "PAK: Rapid Assessment of Sexual Harassment In Public Transport and Connected Spaces in Karachi."

Figure 2: Women's Physical Mobility and Labor Force Participation



The government has experimented with a variety of policies to improve women's mobility, including women's-only buses and training of women to drive motorcycles; however, to date there is no systematic evidence on the effectiveness of these interventions. There also remain concerns regarding their financial sustainability and scalability.

This study aims to assess the impact of urban public transit infrastructure on labor markets for women and men. The study incorporates two major components:

Component 1: A quasi-experimental study of two major new infrastructure arteries, the Lahore Metrobus or Green Line Bus Rapid Transit (built in 2013) and the Lahore Orange Line light rail (currently under construction). This study identifies a more comparable control group than used in most previous studies: areas which were slated for potential routes in a plan from the early 2000's, but have not received them. This study uses a quasi-experimental difference-in-differences approach, in which the treatment group will be areas within a short distance of newly built stations, while the control group will be identified on the basis of both of those lines which have been planned, but have not yet been built, or have been indefinitely postponed. Because these areas have been selected for potential or future routes, they are likely to be comparable overall to the areas selected for these new lines.

Component 2: The research team is working with the engagement of senior policymakers on a Randomized Controlled Trial in Lahore, which experimentally varies mixed and women's-only routes in a transport intervention that provides commuters door-to-door "pick and drop" service. Based on findings in the preparatory stage of the research, this kind of service may be the deciding factor for many women to take up a job, because it allows them reliable and safe transport to and from work. This could be incorporated into the government's transport policies on a larger scale, to complement traditional public transport modes.

The intervention will be implemented as a van service by a private operator during the RCT as a demonstration pilot which will have applicability on transport and employment-related projects in three ways. First, it will quantify the effect of transport on labor market outcomes, forming a basis for analysis of expected return on investment in transport infrastructure. Second, the findings will inform design and planning decisions for the transport infrastructure, such as whether to designate separate women's-only feeder routes, and complementary interventions, such as street lighting around stops: if safe transport from door to door has significant economic impacts, these approaches would clearly be justified as part of public transport investments. Third, after the RCT, if the intervention is found to be effective, the team will work with the government towards its scale-up as a public-private partnership, using the same modalities that the government currently uses to provide bus routes through Lahore Transport Company and/or the Punjab Mass Transit Authority. In addition, the findings on the impact of transport on labor markets will inform the planning of future public transport infrastructure.

Note that the information about the door-to-door “pick and drop” transport service is conveyed through Job Talash, a call center-based employment assistance service developed by the researchers. Job Talash is not an intervention but acts as a unique measurement tool for labor market supply and demand side outcomes associated with this RCT. It connects survey respondents who express job interest at baseline to employers in the employer survey that have job vacancies. Job Talash is described in more detail in section 2.2.4.1.

0.1. Literature Review

Component 1: Mass Transit Quasi-Experimental Evaluation

Our research relates to the literature on the effects of urban transport connections (see Redding and Turner (2015) for a review). Only a few studies in this literature include data from developing country cities (Tsivanidis, 2017; Gonzalez-navarro and Turner, 2016; Baum-Snow et al., 2017)[5].

Some papers (Gibbons and Machin, 2005; Glaeser et al., 2008; Billings, 2011) use natural experiments such as the introduction of new lines or comparison lines; in general these still rely on before and after changes to identify the effect of interest, relying on strong assumptions about time trends, or use areas further from stations as a comparison group, which relies on strong assumptions about the comparability of these areas. Some papers (such as Baum-Snow et al. (2017); Tsivanidis (2017)) also incorporate instruments based on historical or geographic factors that made some areas more likely to receive new transport connections. Because we have an original plan with a number of routes for comparison, in addition to rich baseline data to allow for matching on baseline observables that determined line sequencing, we are able to improve on the identification strategies used in most of this literature.

In addition, most work on this topic uses aggregate sources of data such as real estate prices, night lights or repeat cross section census data (Baum-Snow and Kahn, 2000, 2005; Gonzalez-navarro and Turner, 2016)). Such data cannot be used to distinguish between changes for an existing population and sorting mechanisms, in which one group of households moves in and perhaps displaces existing residents in an area with new access to transit. Thus a net increase in transit use in an area could simply represent more transit users moving in after a station opens. A few studies (Glaeser et al., 2008; Tsivanidis, 2017) test this directly, and have found substantial evidence of residential sorting. Because we collect household residential histories, we are able to rule out sorting for our estimates of interest.

Finally, these papers focus on changes in population, labor and housing markets; in many cases they do not observe commuting behavior directly. While our broader project investigates effects of Lahore's mass transit system on these markets, in this study we focus specifically on commuting patterns, and in particular sustainable commuting on public transport. Thus this study relates most closely to Baum-Snow and Kahn (2000) and Baum-Snow and Kahn (2005), who study the impact of US urban rail transit expansions on public transport ridership. Baum-Snow and Kahn (2005) find that these effects vary dramatically from negative to positive depending on the city and the distance from the central business district, but the modal estimate is insignificantly different from zero. In particular, their results for many cities indicate a negative impact on areas close to the central business district. This may be suggestive of sorting, which they are not able to address with the repeat cross section census data used. In contrast, we find a robust positive impact, which we can attribute to changes in behavior of existing residents, not sorting.

[5] (Harari, 2015) uses an alternative approach using Indian data to identify the effects of higher commuting costs due to the geographic spread of a city on similar outcomes.

Component 2: Transport to Work RCT

There is limited evidence quantifying the effect of urban public transport investments on economic outcomes, particularly in developing countries (Moretti 2014), in part due to the difficulty of identifying appropriate comparison groups for areas receiving new transport investments. New transport routes are often accompanied by coincidental changes in economic and social variables in areas that attract government or private transport investment.

The opening of a new line has been used as an identification strategy: for example, Holzer, Quigley, and Raphael (2003) studied the opening of a new urban rail line in San Francisco and found an increase in hiring of an ethnic minority group (Latinos) who on average had less vehicle access. However, this approach still faces the important problem of identifying an appropriate comparison group. The Holzer et al. study compared trends in treated areas between two groups, one of which is plausibly more intensely affected by the treatment. However, for their estimates to be unbiased, we must assume a similar secular time trend between Latinos and non-Latinos, an assumption which could easily be violated. Our related work (Majid, Malik, and Vyborny) improves upon this by using proposed and cancelled lines as a comparison group for the major infrastructure investment of the BRT.

Work on urban public transport and spatial mismatch of unemployed workers to work opportunities is similarly limited (e.g. Cropper et al. 2007, Gulyani et al. 2006, Yepes and Lall 2008). The existing work on transport interventions has focused more on road connectivity to rural areas (e.g. Khandker et al. 2006), not urban and peri-urban areas. Very few studies are able to credibly identify a causal effect of transport on labor market outcomes; however, those with credible identification suggest that transport has an important impact at least on job search (Phillips 2014 among unemployed jobseekers in Washington, DC, Franklin 2014 among job seekers in Addis Ababa, Ethiopia).

Research on how norms affect women's labor force participation mostly focuses on whether it is acceptable for women to participate in the labor force at all (e.g. Tolciu and Zierahn 2012), rather than exploring norms around specific constraints that may play a role and could be mitigated by policy, such as mobility and transport.

Safe and acceptable urban public transport is an under-researched intervention for women's economic empowerment in many developing countries. Some areas have started to implement public transport interventions targeted at women, such as the women's-only carriages on the Delhi Metro system in India. This has been seen as a highly successful initiative; similar approaches have been initiated in other cities, such as Cairo, Beijing and Rio de Janeiro (NPR 2013). Yet the impact of such initiatives on women's empowerment and economic outcomes has not yet been rigorously evaluated, in part due to the difficulty of identifying an appropriate comparison group or counterfactual.

Our study contributes to the existing literature in three ways. First, spatial frictions have been documented as a mechanism for gender disparities in access to education (Muralidharan and Prakash 2017, Cheema et al. 2017, Burde and Linden 2013, Jacoby and Mansuri 2011, Borker 2018). A smaller number of studies (Siddique 2018; Chowdhury 2019) show that women reduce labor force participation after reports of sexual violence, but this is not directly linked to the mobility constraint and could be driven by alternative mechanisms. Our study is the first to our knowledge to directly quantify the impact of constraints on physical mobility and transport on female labor market participation, and demonstrates a large and gendered impact of these frictions.

Second, our sample is unusual in that it includes people who were not participating in the labor market at baseline. We show that non-participants can be induced to search for jobs. This shows that non-participants may have high latent returns to search, which is particularly relevant given gender gaps in labour force

participation. It also suggests that experimental studies of urban labor market frictions studying only active jobseekers may understate the importance of these frictions.

Third, we advance the literature on these frictions by studying vacancy- and firm-level outcomes. Our interventions incorporate variation at the firm level. This identifies the effect of these frictions on firm-level labor demand and labor productivity. Most existing research identifies only applicant-level effects and cannot differentiate between job creation and job displacement.

0.2. Rationale for Impact Evaluation Study

Understanding how firms are affected by being able to more easily hire women substantially enhances the public policy implications of improved transport for women. For instance, it allows the researchers to analyze whether any change measured on the labor supply side represents a shift between treated and untreated individuals in the same jobs, or if firms are actually able to hire and retain workers who are a better match for the job, or more women, as a result of the treatment. This is important for understanding the implications of transport interventions for overall economic productivity and growth.

The findings from this research are useful to policymakers in several ways. First, it establishes a quantitative evidence base on the importance of urban transport for employment. This helps to inform the national urban transport plan, which has been a top priority for the national and Punjab governments; several policymakers have reached out to actively follow up on discussions of this project to request information on the research findings. In particular, it helps inform policymakers in the following ways:

1. Establishing the quantitative effects of high-quality transport on jobseekers' access to jobs and employers' access to labor, particularly skilled labor;
2. Informing potential policies for the vehicles themselves, such as whether to include physical partitions for the women's section (not currently incorporated in the Lahore BRT),
3. Informing potential features of feeder routes to the main BRT arteries, such as geographic placement and vehicle choice (since small vehicles are harder to partition by gender, larger ones which can be partitioned may be important) and
4. Informing optimal fare policies through estimation of demand, through a cross-randomization of randomly assigned price levels in Component 2 and analysis of heterogeneity of effects by geographic area and individual / household characteristics.

Second, Component 2 tests out and directly informs decision-makers on the specific costs and benefits of a transport-to-work intervention. After the study, this could be operated privately or through a public-private partnership (following existing institutional arrangements with PMTA or LTC, which operate existing transport services through contracts with operators). The research team anticipates that the intervention could become financially self-sustaining for some areas. However, in the medium run the intervention might require public support in more remote or marginalized areas, which may be a priority for public agencies in order to promote economic and social integration.

1. Component 1: Mass Transit Quasi-Experimental Evaluation

1.1. Intervention

1.1.1. Description

The Green Line is a Bus Rapid Transit line, built in 2012-2013. It crosses the entire city of Lahore from north to south, covering a distance of about 26 km. It carries approximately 200,000 riders per day, approximately equivalent to 2% of the city's entire population. Like other Bus Rapid Transit systems, the Green Line comprises a system of buses running with a reserved lane to -allow high-speed transit. However, unlike some BRTs, this line incorporates extensive physical infrastructure in the form of dedicated overpasses. This feature was included in part to allow for new buses to run in addition to other vehicle traffic while minimizing land acquisition to widen the roadway in a congested city.

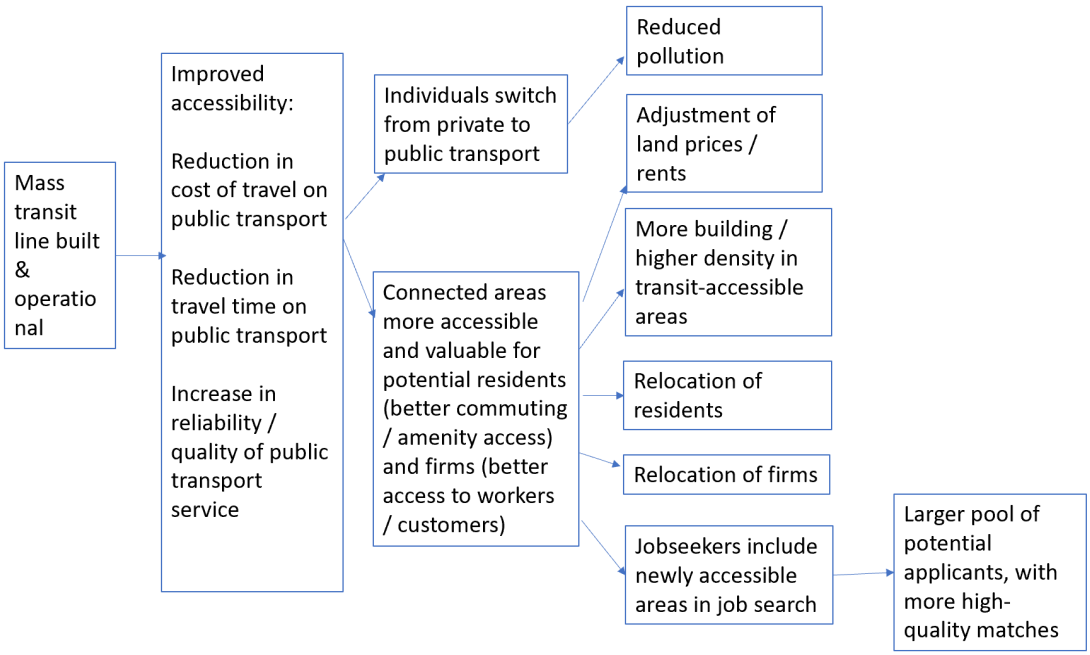
Overall the Green Line BRT is known to have a better quality of service than alternative buses in a number of ways. The buses run on a very high frequency and have less variability in arrival time due to the dedicated lane. In addition, stops have dedicated spaces which are protected from traffic, well lit, and have CCTV surveillance, unlike standard bus stops which are often no more than the side of the road without a sidewalk.

The fare was set at the level of 20 PKR (approximately 20 US cents) regardless of distance, while existing bus fares ranged from 15 to 45 PKR depending on distance. The line also reduced travel time from one end to the other from approximately 1.5 hours to 45 minutes. Hence the Green Line decreased travel time and costs substantially for many potential trips in the city.

1.1.2. Theory of Change

Figure 3 shows the Theory of Change for the Component 1 evaluation.

Figure 3:Theory of change: Quasi-experimental study of mass transit



1.1.3. Intervention monitoring plan

The government has an extensive monitoring process to check performance of the mass transit line. This is done through the Punjab Mass Transit Authority's command center, in which CCTV from all stations and progress of all buses on the line is monitored. The researchers visited this center to learn about the mass transit line. However, because this component of the study is quasi-experimental, the researchers are not involved in monitoring.

1.2. Evaluation questions, design, methods, sampling and data collection

1.2.1. Primary and secondary evaluation questions

The broader evaluation aims to answer the following questions:

1. How do investments in urban transit affect labor markets?
2. What kinds of areas are likely to benefit most from these investments? Can they help to integrate periurban and other marginalized areas of the city?
3. How do these investments affect men and women differently? How does women's-only transport affect women differently from mixed-gender transport?
4. How do these investments affect the markets for housing and commercial land, and the density of the built environment? Are the benefits of better access to employment priced in to the housing market and if so, how quickly? How is this likely to affect welfare?

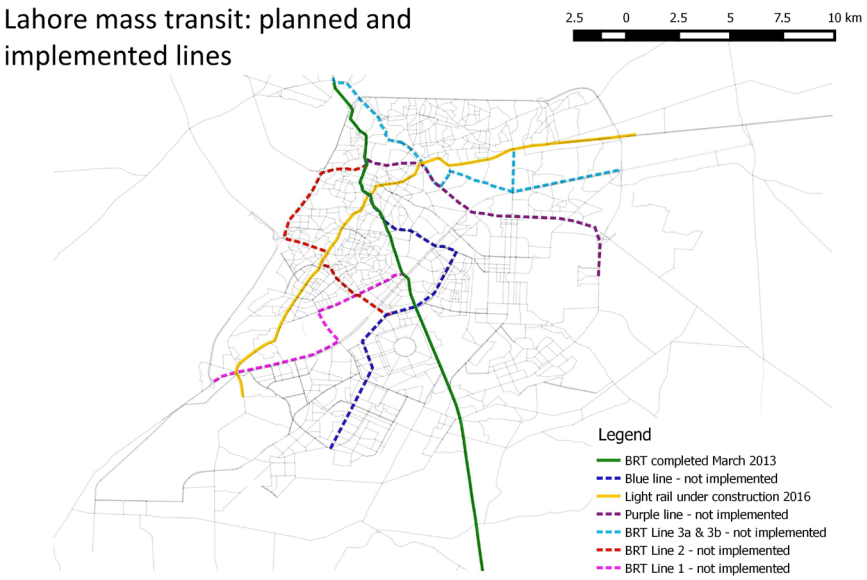
This component (the quasi-experimental study of the mass-transit line) will examine all four of these questions, with the exception of the comparison of women's-only and mixed-gender transport in question 3.

1.2.2. Evaluation design and methods

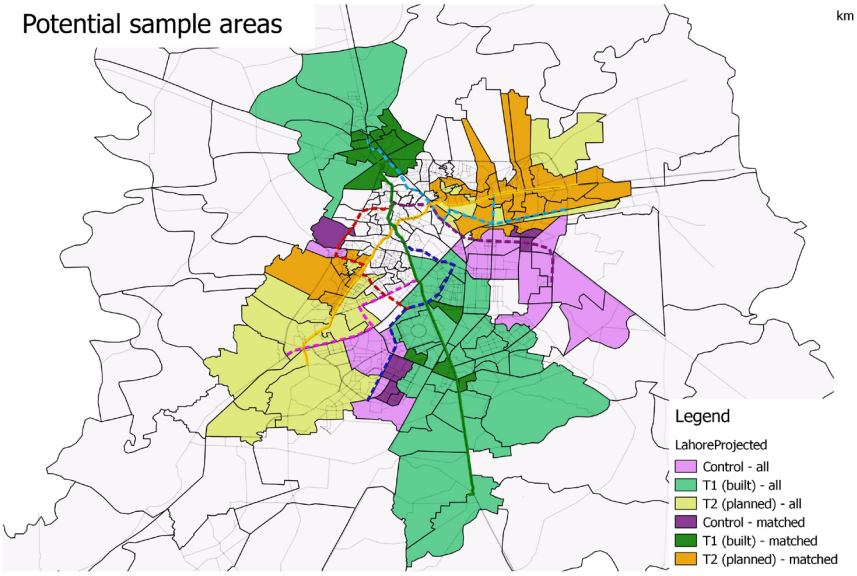
1.2.2.1. Evaluation design and timeline

This component is a quasi experimental study of two major new infrastructure arteries, the Lahore Metrobus or Green Line Bus Rapid Transit (built in 2013) and the Lahore Orange Line light rail (currently under construction). The basis of our quasi-experimental strategy is comparison between areas near the line already built and those near the lines which have not yet been built. Figure 4 illustrates this strategy.

Figure 4: Illustration of identification strategy



(a)



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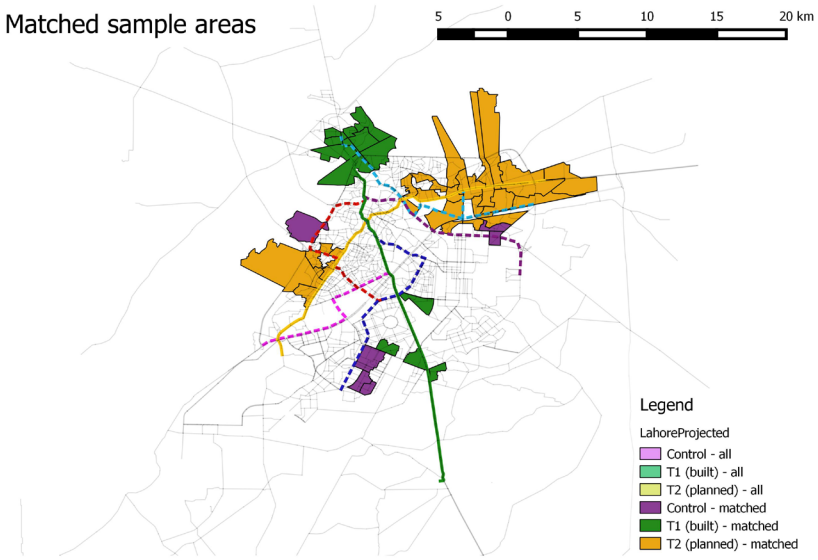


(c)

To further strengthen the identification strategy, we incorporate several evaluation methods.

First, we use matching methods to select and sample data from areas which are similar on observables before the first transit line was built (Figures 4(b) - 4(c)). To address the possibility of pre-trends, we match on data from two points in time before transit was built.

Second, we incorporate fixed effects for bands of distance from the planned stop. This effectively compares areas less than 1 km from a built stop with those less than 1 km from a planned stop. Similarly, it compares areas 1-2 km from a built stop with those 1-2 km from a planned stop, and so on.

Thus we require a much weaker assumption for identification of the causal effect of access to transit: areas that were both slated for a transit stop, both the same distance from the planned stop, and were similar on observables both twelve and three years before transit was built, should not differ on unobservables that affect our outcomes of interest. We also use recall data to construct a quasi-panel dataset, so that the assumption is further weakened to require only that such observably similar areas have parallel trends. This combination strategy ensures that the treatment group is comparable to the comparison group, so we can attribute differential changes to the introduction of the new transit.

Third, we address the possibility of positive or negative spillovers from treated to comparison areas. We incorporate a buffer distance in our sampling procedure, so that areas close to both “control" and “treated" transit stops are not selected. We also use rich data we collected on the actual accessibility by public transport from each enumeration block studied to the center of the city. This allows us to incorporate any effects on the control areas into our measurement. We incorporate this measure into an instrumental variables specification that allows us to use the introduction of mass transit to estimate the impacts of an improvement in public transport accessibility; this is similar to adjusting for "non-compliance" with the instrument (Angrist and Krueger, 2001).

The employer-side analysis with the employer survey supported by 3IE, in conjunction with rich data from Job Talash (see section 2.2.4.1 for description of Job Talash), will allow us to measure the effect of this

intervention on candidate pool size and composition, as well as match quality proxies for employers. This allows us to speak to whether the transport simply replaces a control jobseeker with a treated jobseeker, or actually changes the scope of the labor market and improves match quality.

1.2.3. Ethics

This component of the project was approved by the Duke IRB under protocol number D0178. Because this component is a quasi-experiment, the ethical considerations are limited to those related to survey respondents:

- Consent to respond to the survey: For each survey data source, enumerators were carefully trained on a protocol for obtaining respondent consent before proceeding.
- Burden of time taken to respond: All surveys were kept limited in length to reduce the burden on respondents. Several sources of compensation or benefits were offered. For data source 1, household respondents were also entered into a drawing to win mobile credit. For data source 2, the survey was only 5 minutes in duration thus the burden was minimal. For data sources 3-6, jobseekers and firms receive the benefits of the Job Talash service for free.
- Protection of personal information: This is achieved through limited access to identifying data and data encryption using BoxCryptor.

1.2.4. Sampling and data collection

1.2.4.1. Primary quantitative and qualitative baseline surveys

Six main sources of primary data are used for this evaluation:

1. A HH survey and community survey sampled in areas around the quasi-experimental treatment and control lines (data collection complete);
2. A survey of 2,500 riders on the Lahore Metrobus (data collection complete);
3. A survey of real estate agents from across the metropolitan area conducted alongside the Job Talash employer survey (data collection in progress);
4. The household survey and signup data from the Job Talash household-side enrollment (data collection complete);
5. The employer survey and signup data from the Job Talash employer-side enrollment (data collection in progress);
6. The administrative job matching data from the Job Talash job matching platform (data collection in progress).

In addition to these primary data sources, the study also used administrative and secondary survey data.

Administrative data of daily total ridership numbers by station (boarding and alighting) and individual trip data for a period of one month were provided by the Punjab Metropolitan Transit Authority. These are used to weight the sample for the ridership survey.

For secondary survey data, we use microdata from a 2010 survey of 18,000 households that the government gathered as a part of preparation of its urban master plan to identify and match areas that are similar at baseline between treatment and control lines. The HIS survey was sampled by the 228 urban zones and was designed to be representative of the entire metropolitan area. It includes household information, information

on a roster of adult members, as well as a trip diary for each of these members. In addition, we use block-level data from the 1998 census and microdata on industrial activity to select zones as follows. Incorporating data from both 1998 and 2010 in the matching procedure allows us to address the possibility of differential trends between the two groups.

We describe data collection from the primary data sources below.

1.2.4.1.1. Community and household survey in matched sample

Within the matched sample of zones we selected 550 random coordinates as sample points, using probability proportional to the population density in each area estimated from satellite imagery such that the data represent the population in the zone. At each point, an enumerator interviewed a real estate agent or other community member well informed about local real estate markets and local amenities. These respondents reported on local real estate purchase and rental prices for commercial and residential property for the current period (end 2015 / beginning 2016), the year before the Green Line was completed (2012), and three years before (2009). They also reported the typical travel time on different modes from that sample point to a well-known central point in Lahore (Kalma Chowk). Enumerators worked with these respondents to calculate the total time and cost of the best route from the survey sample point to the central point using only public transport (BRT, bus or wagon) and walking, at 9AM on a weekday (morning rush hour). This approach has the advantage of allowing for the actual frequency of public transport services, congestion and other real-world factors[6]. These are our main measure of travel time and cost on public transport.

The household survey included a total of 12,300 households. At each sample point, the survey team drew a random start direction and selected one every three households to interview. Response rates were approximately 70% and were balanced across treatment arms (Table 1).

The survey included a roster of all household members age 15-65. For each such member, it covered work and commuting information. These variables were collected for the current period (end 2015 / beginning 2016) and the year before the Green Line was completed (2012). Respondents were also asked when the household moved into the area and whether each member had joined the household in the last three years, allowing us to identify in-migrants to the community. The survey also included questions on household characteristics including the household's vehicle ownership.

Women were often the main respondents, but in some cases did not have complete information on male family members' activities. Therefore we supplemented the respondents' reports with a shorter survey of a male household member which only covered confirmation or completion of records on male family members' employment. If the male was available at the time of the survey this was completed immediately afterwards; otherwise it was done by telephone after the field interview.

This allows us to collect a two- or three-period panel of key variables for households and adults; in the case of variables reported for 2009, this covers approximately 140,000 person-round observations. These recall baseline observations are also balanced across treatment arms (table available upon request).

Because of the questions on new household members and how long the household has stayed in the area, we are able to identify in-migration to the residential area through a migration history. However, unlike a traditional panel, the data do not cover households that moved out of the area. Sixteen percent of households

[6] These factors would likely be understated in a GIS trip analysis given that the frequency of public transport services is often not in line with the official schedule, and some routes that appear on official maps are sometimes not operated in practice.

moved into their current residence within the last three years, i.e. after the Green Line was built, demonstrating the importance of sorting as a potential mechanism. These households are excluded from our main estimates of interest. There is no significant difference in the levels or composition of migration into the treated areas (table available upon request).

To address out-migration, we conducted a telephone survey with respondents from the 2010 baseline cross-section collected by the government. (We were not able to use this sample as a basis for our main survey because of high attrition due to the destruction of contact information other than the telephone numbers by the government agency that collected the data.) We find no evidence of differential attrition or outmigration in the sample reached in the phone survey (table available on request).

Retrospective reporting by households and community respondents may be subject to recall bias, which is a limitation of the 2015-6 data. For this reason, we consider the panel component of the analysis as a robustness check rather than the main analysis. We include both cross-section and recall-panel based specifications in all the results. The main results presented in the working paper (see Appendix A) and this report are robust across these specifications.

1.2.4.1.2. Local business count

At each sample point, the supervisor also had to count and categorize any business interspersed between households that covered over the length of the "random walk". This will be used as a measure of local business activity.

1.2.4.1.3. Community respondent survey

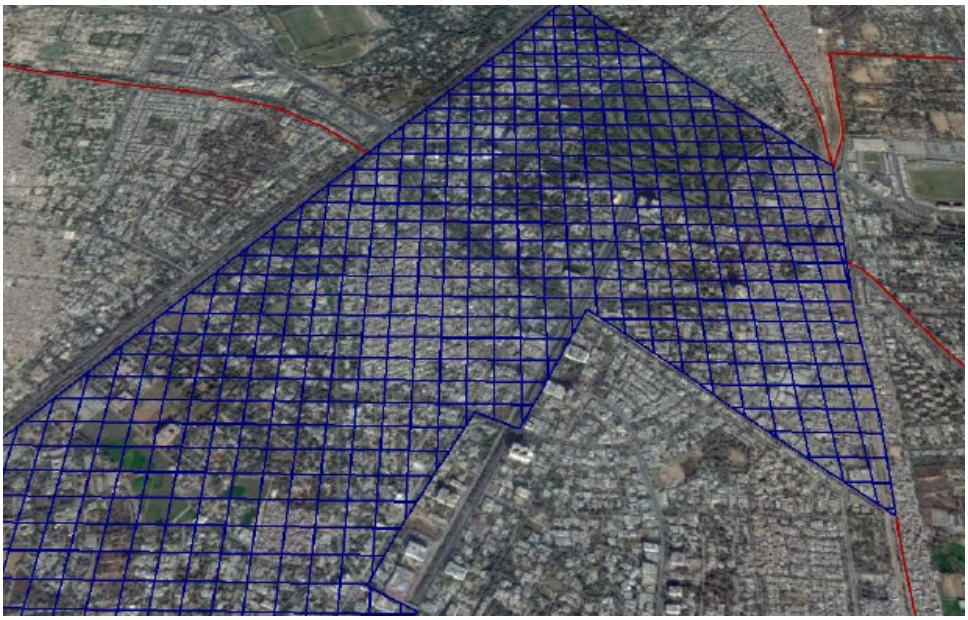
At each sample point, one community respondent was also interviewed. The preferred respondent was a real estate agent. In case a local real estate agent could not be identified, the supervisor would identify another local community key informant well-informed about the area including real estate transactions.

This survey covered a reference area of a 10-minute walk radius around the sample point. Again, it covered data from the time of the survey as well as 2012 and 2009, and covered community characteristics including key amenities, business activity; transport time and costs at present and in 2012 on various modes from the area to central Lahore; real estate prices and rental costs for residential and commercial land with and without buildings; and incidents of re-development and forced evictions. Respondents were also asked to estimate household-level movement in and out of the community year by year over the past six years, to help address the lack of this information in the household survey.

1.2.4.1.4. Satellite data

To quantify building density, we coded building coverage in historical satellite images to measure any changes in building density. The treatment and control areas are divided into grid cells and each cell is observed and coded for the approximate number of buildings it contains. Figure 5 shows an example. This density variable will be used as an additional outcome variable to help capture land market effects.

Figure 5: Example satellite image used to measure density



1.2.4.1.5. Rider survey

We conducted a survey of 2,500 riders on the BRT by approaching riders as they exited the station. We selected the start and end stations on the line and one every three stations in between, and randomly selected morning, mid day or afternoon shifts for interviews. We weight the estimates using administrative data on rider volumes provided by the Punjab Mass Transit Authority. Thus the survey data is representative of riders, other than those who ride in the early morning or late evening (before 8AM or after 6.30PM). Approximately two thirds of riders approached responded to the survey; in the case of non-response, enumerators recorded observable characteristics about the individual. Respondents were asked about their age and education, purpose and destination of their trip, the time and cost of the trip, their past travel behavior, and their hypothetical willingness to pay different prices for tickets on the BRT.

1.2.4.1.6. Data sources 4 to 6 from Job Talash

Please refer to section 2.2.4 for an explanation about data sources 4 to 6.

1.2.4.2. Sampling

1.2.4.2.1. Sampling for data sources 1 and 2

To address the differences in lines on such observable factors, we use matching methods on the treated and control areas to select and sample data from areas which are similar before the first transit line was built.

While the Green Line was a high priority route, not all areas it connects would be high priority than those on the other planned lines. We select geographic areas among the areas served by these lines and the comparison lines that were similar before transit. The intuition is that after this selection, we identify areas that were not in themselves higher priority, but happened to be along a higher priority route. This allows us to address differences on a rich set of baseline observables between the built and unbuilt lines.

We matched on the level of a zone; Lahore has 228 zones, with populations ranging from 10 to 50,000. We use microdata from several sources for the matching. First, we use microdata from a 2010 survey of 18,000 households that the government gathered as a part of preparation of its urban master plan. This survey was sampled by the 228 urban zones and was designed to be representative of the entire metropolitan area. It

includes household information, information on a roster of adult members, as well as a trip diary for each of these members.

In addition, we use block-level data from the 1998 census and microdata on industrial activity to select zones as follows. Incorporating data from both 1998 and 2010 in the matching procedure allows us to address the possibility of differential trends between the two groups.

Our objective is to select T1 areas, i.e. those that have access to the completed mass transit, the BRT or Green Line; T2 areas, those that would have access to the line under construction, the Orange Line, when it is completed, and control areas, those that would have access to the planned lines that have not been implemented.

All else equal, areas closer to a station are expected to be more affected by access to that station. However, to avoid measuring spillovers in our estimated treatment effect, control zones must be distant from T1 and T2 stops; similarly, T2 zones must be distant from T1 stops and vice versa. To ensure this, we selected an initial set of zones for analysis using distance from the planned and actual stations using successive radii as follows: for a series of radii X and Y, if the zone centroid was within X km of a control station station and was at least Y km from any T1 or T2 station, it was considered a control zone. Table 5 shows the full set of criteria used. So a zone that was within 2km of a control station and at least 3km from the nearest T1 or T2 station, it would be considered a control zone; or if it was within 3km of a control station and at least 4.5km from the nearest T1 or T2 station, it would be considered a control zone, and so on. Similarly, a zone would be considered a T1 zone if it was within 2km of a T1 station and at least 3km from the nearest T2 station; and vice versa.

Table 1: Radii used for selecting potential treatment and control zones and avoiding spillovers

To be assigned to treatment group i, Zone centroid must be:	
$<$ X km from a treatment i station	$\geq$ Y km from other $\geq$ treatment stations:
2	3
3	4.5
4	6
5	7.5
6	9
7	10.5

Figure 4(b) shows the 121 zones selected according to this procedure. Note that areas in the center of the planned transit system, where all the lines interchange, are therefore excluded.

Despite this procedure, some degree of spillovers may still exist as a small number of commuters travel longer distances on another mode before boarding the mass transit line. This would attenuate a reduced-form treatment effect comparing treated and untreated areas. However, since we use distance to a stop on the built line as an instrument for a measure of public transport accessibility, these will account for such an effect on comparison zones (Angrist and Krueger, 2001).

Within each treatment group, we use a matching procedure to select zones that were similar on pre-treatment 36 characteristics. We use a rich set of variables from 2012, which includes key aspects of the markets we study, including rental values, vehicle ownership, commute times, labor force participation, and wages, as well as more general characteristics. We also use the full set of educational and demographic variables available from the 1998 census. This is a more limited set of variables, but it allows us to identify zones that had similar time trends in these characteristics. The full set of variables used for matching is listed in Table 6.

To carry out the match, we construct the Mahalanobis distance on vector of baseline characteristics between each C zone and corresponding potential T1 zones:

$$D_M(x) = \sqrt{(x_i - x_j)' S^{-1} (x_i - x_j)}$$

Where

- xi and xj are vectors of baseline characteristics of a given control and T1 zone, respectively
- S is their covariance matrix

We then select pairs of C and T1 zones with $D_M < R$, where R is a fixed radius. Since the different sources of matching data have different units of observation, we calculate four different values of $D_{M,g}$, once for each group g of variables listed in Table 6 and set a radius R_g for each of them. To be selected as a match, a pair of zones must meet all the matching criteria, i.e. $D_{M,g} \_ R_g \forall g$.

We repeat the procedure for pairs of C and T2 zones. Finally, we select control group zones that have at least one matching T1 and one matching T2 zone. We allow multiple matches; this will be addressed in estimation using weights, as discussed below.

This final set of 50 zones, shown in Figure 4(c), is well-balanced in 2010 and 1998. We select a representative sample of households from these zones for our household and community survey.

In some cases, a small control zone might be matched to a large T1 zone or vice versa. In addition, we allowed for multiple matches. In all specifications, we weight observations to correct for this, using the following procedure. Denote each control zone as i 2 1...I, and each T1 zone as j 2 1...J . Denote M_{ij} as an indicator equal to 1 if zones i and j were matched and zero otherwise. We standardize the zone weight for control zones at 1 and calculate the zone weight for zone j as:

$$W_j = \sum_i \frac{M_{ij}}{\sum_j M_{ij}} \qquad (1)$$

Thus the weight for each T1 zone increases in the number of control zones it is matched with, but decreases in the number of T1 zones that its counterpart control zones are matched to. We repeat the procedure for the T2 zones.

Then the weight applied to each household in zone g is defined as W_g / N_g , where N_g is the number of households sampled in zone g.

Table 2: Matching variables

Variable	Unit of observation
A. Masterplan zone-level data: Simple match on each variable	
Distance to center	Zone
Population density	Zone
B. Punjab Directory of Industries: Mahalanobis match group 1	
Number of manufacturing firms, weighted by (1 / distance from zone centroid)	Zone
Total firm investment, weighted by (1 / distance from zone centroid)	Zone
C. 1998 Census: Mahalanobis match group 2	
Proportion male completed primary education	Census block
Proportion female completed primary education	Census block
Proportion male completed matriculation	Census block
Proportion female completed matriculation	Census block
Proportion age 10 or older	Census block
Proportion age 18 or older	Census block
Proportion religious minorities	Census block
D. 2010 Lahore Masterplan Household Integrated Survey: Mahalanobis match group 3	
Any individual income	HH member
Level individual income	HH member
Log income	HH member
Education high school or less	HH member
Higher education	HH member
Trip cost in reference day	HH member
Trip duration in reference day	HH member
Years at location	Household
Owns house	Household
Rent paid per month	Household
House area	Household
Number of rooms	Household
HH income	Household
Monthly transport expenditure	Household
Bicycle ownership	Household
Motorcycle ownership	Household
Number of HH members living at HH	Household
Number of HH members living away from HH	Household
E. Neighboring zones: Mahalanobis match group 4	
All variables in Panel D, for all HHs in neighboring zones (centroids $\leq$ 3km)	HH / HH member

1.2.4.2.2. Sampling for data sources 3 to 6

Please refer to section 2.2.4 for the discussion on sampling for data sources 3 to 6

1.3. Findings

1.3.1. Intervention implementation fidelity

Please refer to section 1.3.2.1.

1.3.2. Impact analysis

1.3.2.1. Descriptive statistics and balance tables

1.3.2.1.1. Description of the quantitative sample

Table 3 shows summary statistics for selected variables from the survey. The sample covers areas from 2-17 km from the central point of the city used as a reference point in our study (Kalma Chowk). About a quarter of the individuals in the sample work outside the home. Conditional on working, over two thirds commute by some motorized mode (i.e. they do not walk or bike to work) but only about seven percent commute via public transport. Overall, mean transport time is 24 minutes.

Table 3: Summary statistics: Household survey

	count	mean	sd	min	max
Work outside	33597	0.260	0.44	0	1
Motorized commute	33620	0.176	0.38	0	1
Public transpport commute	33620	0.017	0.13	0	1
Public transport commute (conditional on work)	8700	0.067	0.25	0	1
Gender	33663	1.585	0.49	1	2
Age	33663	32.474	14.25	17	85
Education	33263	7.782	5.39	0	18
Distance to central point - km	33663	8.179	3.52	2.396217	17.01249
Observations	33663				

Table 4: Baseline balance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Public transport commute		Commute time		Motorized commute		# Motorcycles	
Treatment area (T1 - near built stop)	0.0024	0.0005	0.4689*	0.2814	-0.0034	-0.0109	-0.0258	0.0044
	(0.0022)	(0.0025)	(0.2426)	(0.3150)	(0.0063)	(0.0074)	(0.0298)	(0.0357)
Area near stop under construction (T2)		-0.0030		-0.2858		-0.0113		0.0466
		(0.0025)		(0.2347)		(0.0070)		(0.0373)
Observations	33210	33210	28263	28263	33210	33210	8056	8056
Control group mean	0.0200	0.0200	3.1100	3.1100	0.1800	0.1800	0.9300	0.9300
Donut FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additional covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses clustered by zone
="* p<.1 ** p<.05 *** p<.01"

1.3.2.1.2. Description of the qualitative sample

The main qualitative work in this component focused on real estate agents who were responding as key informants on local development, transport and other implications of the intervention. The areas selected for these interviews are similar to the matched sample as a whole (i.e. data sources 1-2).

1.3.2.1.3. Cross-tabulations, correlation and/or regression analysis using quantitative data

The use of planned lines as a comparison may be the most plausible identification strategy used in the literature from developed countries (Redding and Turner, 2015). However, it requires the assumption that the order of lines to be built is uncorrelated with unobservables that affect the outcome variable. We improve on this strategy to relax this assumption in three ways.

First, we observe a rich set of baseline and pre-baseline variables, including the same set of variables used by transport planners to select routes and the order of routes. We use matching methods to select and sample data from areas which are similar on observables before the first transit line was built. To address the possibility of pre-trends, we match on data from two points in time before transit was built.

Second, we incorporate fixed effects for bands of distance from the planned stop. This effectively compares areas less than 1 km from a built stop with those less than 1 km from a planned stop. Similarly, it compares areas 1-2 km from a built stop with those 1-2 km from a planned stop, and so on.

Thus we require a much weaker assumption for identification of the causal effect of access to transit: areas that were both slated for a transit stop, both the same distance from the planned stop, and were similar on the observables used to select the order of routes, both twelve and three years before transit was built, should not differ on unobservables that affect our outcomes of interest. We also use recall data to construct a quasi-panel dataset, so that the assumption is further weakened to require only that such observably similar areas have parallel trends. This combination strategy ensures that the treatment group is comparable to the comparison group, so we can attribute differential changes to the introduction of the new transit.

We use an instrumental variables specification to estimate the effect of accessibility of public transport, defined as the time it takes to get from a given area of the city to a central point using only public modes (as reported by a community real estate agent in each enumeration block). Because transit stops in fact decreased both the financial and time cost of public transport travel to the center city, we consider this access measure as a proxy for a change in both these costs: an overall measure of public transport accessibility.

We use distance from a transit stop that was built as an instrument for public transport accessibility. The identifying assumption is that conditional on distance from any planned stop, distance from a built stop is exogenous. In other words, an area which is 2km from a stop that is built is similar to an area that is 2km from a stop that is planned but not yet built. Because we are working with a sample of areas that are all slated to receive transport eventually, and are also observably similar at baseline, we assume that these areas would look similar in 2016 in the absence of the new mass transit line. The instrument is an informative predictor of public transport accessibility because the mass transit lines actually built decrease travel time to the center city, while planned stops do not.

We estimate the effects of new transit on outcomes Y_{ig} for individual or household i in geographic zone g:

$$ACCESS_g = \pi_1 + \pi_2 D1_g + \pi_3 D1_g^2 + \pi_4 D_g + \pi_5 D_g^2 + \alpha_d + \eta X_i + \upsilon_{ig}$$
$$Y_{ig} = \beta_1 + \beta_2 \widehat{ACCESS}_g + \beta_3 D_g + \beta_4 D_g^2 + \alpha_d + \gamma X_i + \epsilon_{ig} \quad (2)$$

Where

- D1 is the distance of the enumeration block from the closest built station and D is the distance from any planned station (whether built or not).
- d is a fixed effect for a distance “donut ring", e.g. it is defined as 1 for all enumeration blocks that are between 1-2 km from either a built or unbuilt stop. All standard errors are clustered at the level of the zone (50 zones total).

Using this IV specification allows us to estimate a more meaningful treatment effect than a generic estimate of the effect of being in a treatment area. The latter would differ across different areas of the city, because being close to a new mass transit stop is more useful in an area which is further from the center and/or less well served by pre-existing bus lines.

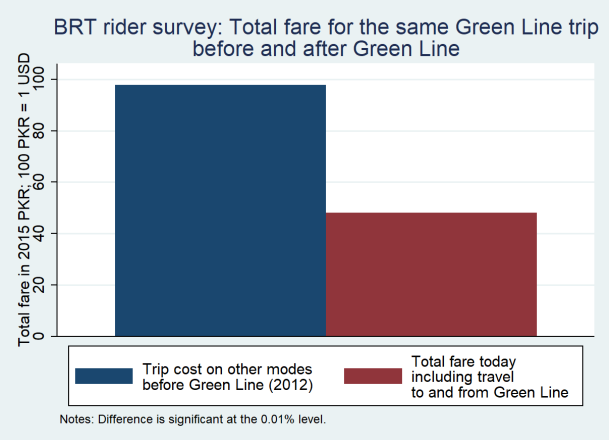
This specification also accounts better for the possibility of spillovers between treatment and control areas: if the new transit line affects accessibility in control areas positively (e.g. individuals take a bus or motorcycle from a control area all the way to the mass transit line and then change onto transit), a simple comparison of treatment and control areas would under-estimate the impact of transit. If it affects accessibility in control

areas negatively (e.g. traveling orthogonally to the new line takes longer because traffic is obstructed by the dedicated lane), a treatment-control comparison would over-estimate the impact of transit. In Equation 2, the effects of the mass transit line on transit accessibility in control areas is already captured in ACCESS. Therefore, under our identifying assumption that D1 is a valid instrument for ACCESS, $\beta\hat{}_2$ in Equation 2 will yield a consistent estimate of the effect of accessibility on Y - the size of the estimate accounting for the observed value of ACCESS across all areas. It effectively readjusts the estimates for incomplete compliance (Angrist and Krueger, 2001).

For selected outcome variables, we also use recall data to construct a quasi-panel dataset, so that the assumption is further weakened to require only that such areas have parallel trends. This combination strategy ensures that the treatment group is comparable to the comparison group, so we can attribute differential changes to the introduction of the new transit.

We also test robustness to estimating Equation (2) including only areas served by the planned line and the line under construction. This helps to address the concern that selection of lines for shorter-term implementation may reflect differences between these areas (such as economic or political priority) that could be correlated with our outcomes of interest.

Figure 6: Rider survey: reported cost of same trip before and after BRT mass transit



1.3.2.2. Research analysis

1.3.2.2.1. Mass transit substantially improved public transport accessibility

Figure 6 shows the reduction in travel cost as reported by riders in our rider survey who report they took the same trip on other modes before 2012 (this makes up 70% of the sample). They report substantial decreases in travel cost. However, these data represent those who benefited from time and/or cost savings sufficiently high to switch to the BRT; they do not represent the effect on the population as a whole.

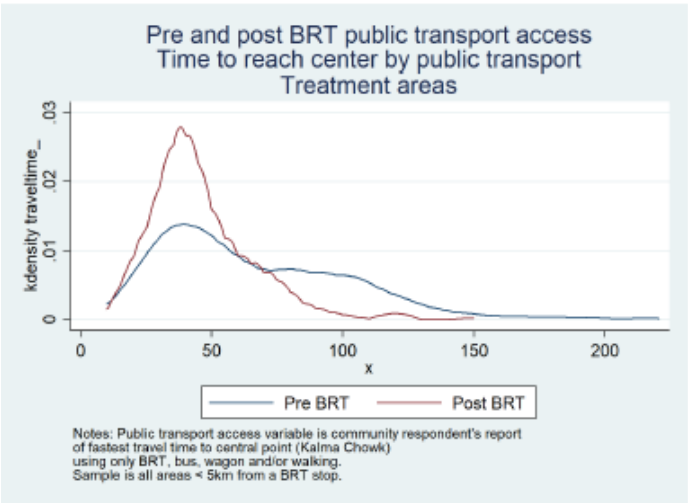
Figure 7 shows the effect of the new mass transit line on travel time and cost to central Lahore in our balanced sample of residential areas. The regression estimates for travel time accessibility are shown in

Table 7 and for travel fare accessibility in Table 8; these represent the causal impact on these sample areas. For every kilometer further from a mass transit stop, public transport accessibility decreases, with an increase of fare of 3.2 rupees (about 3.2 US cents) and a 3.6 minute increase in the travel time required to reach the center by public modes. There are no such trends between the groups in the period preceding the introduction of the BRT. We also estimate a similar specification in , with a binary for "treatment zones", showing that the average effect on the population of the sample zones is a 25-30 minute reduction in time, i.e. a decrease of about one third from the baseline mean of 76 minutes. The mass transit also reduced the public transport fare by 20-30 PKR, or over half the baseline mean. These figures represent a substantial improvement in public transport accessibility to an area including approximately 25% of the population of the city[7].

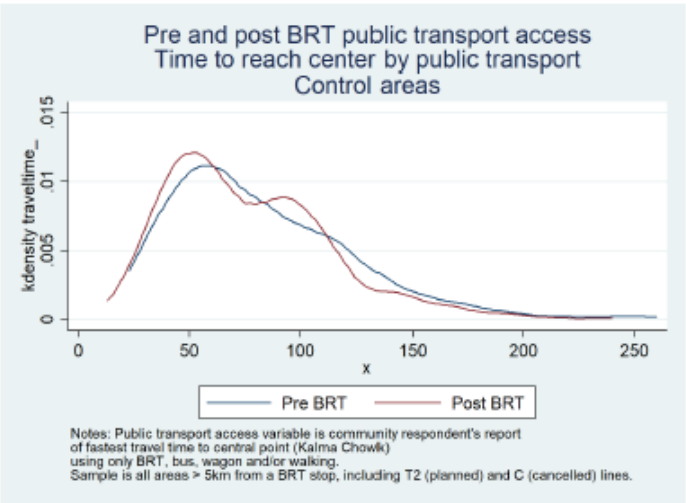
The estimation shown in Table 7 is also the first stage for our IV specification (2), demonstrating that the instrument is informative. In our IV estimates, we use the time measure of public transport accessibility as the independent variable of interest. However, it proxies for overall public transport accessibility, representing both time and cost savings, since the mass transit expansion which is used as an instrument affects both time and cost savings.

[7] This figure includes the population of areas outside central Lahore which are accessible to the new mass transit, i.e. those shown in green in Figure 4(b)

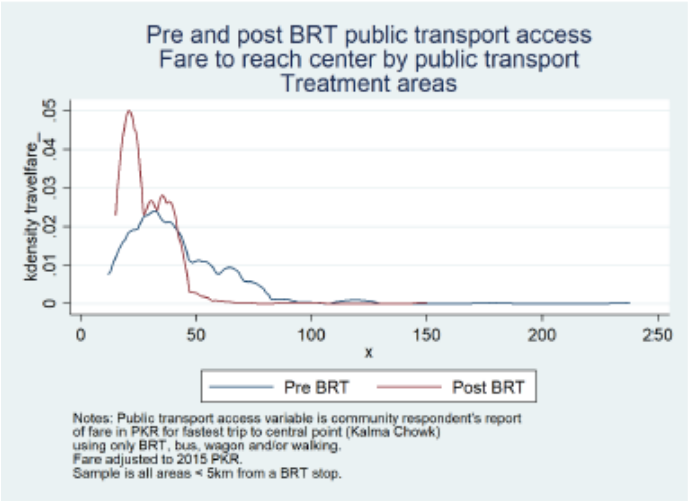
Figure 7: Impact of Green Line on time and cost of travel by public transport



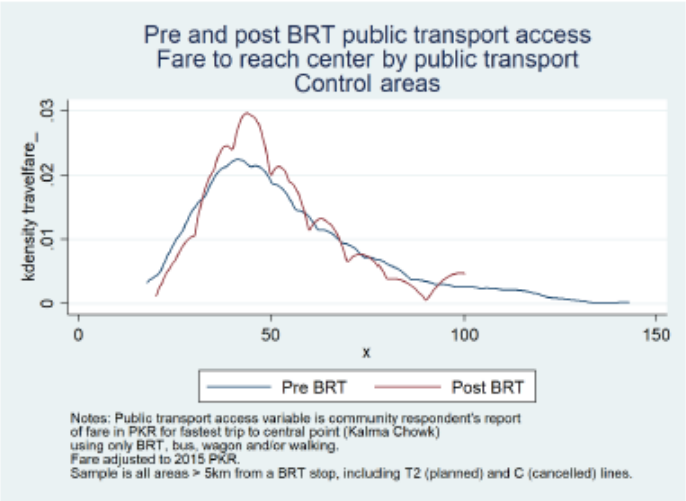
(a)



(b)



(c)



(d)

Table 5: Impact of transit on public transport access to center city - time (IV first stage)

	(1)	(2)	(3)	(4)
	Travel time to central Lahore on public transport			
Distance to closest built stop (T1)	4.1090***	5.8695**	-1.7376	-1.1527
	(0.7587)	(2.3075)	(4.0514)	(4.1134)
Distance to closest planned stop (T1 / T2 / C)	4.6656	-0.1969	4.1292	13.4442
	(3.3002)	(5.5819)	(10.4266)	(30.7939)
Distance to closest built stop sq		-0.1377	0.2137	0.1611
		(0.1669)	(0.2746)	(0.2788)
Distance to closest planned stop sq		1.3666	1.3449	-0.1085
		(0.8409)	(1.5164)	(3.6899)
Post			-36.6992***	0.0000
			(8.5354)	(.)
Distance to closest built stop (T1) x post			7.6071***	7.4238***
			(2.3123)	(2.3564)
Distance to closest built stop sq x post			-0.3515**	-0.3305**
			(0.1455)	(0.1495)
Distance to closest planned stop x post			-4.3260	-11.5433
			(6.4406)	(25.9114)
Distance to closest planned stop sq x post			0.0217	0.9307
			(0.9635)	(3.1278)
Observations	362	362	712	712
Donut FE	No	No	No	Yes
Specification	XS	XS	Panel	Panel

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 6: Impact of transit on public transport access to center city – fare

	(1)	(2)	(3)	(4)
	Travel fare to central Lahore by public transport			
Distance to closest built stop (T1)	3.4200***	4.7071***	-2.7869	-1.1527
	(0.3918)	(0.8746)	(2.3485)	(4.1134)
Distance to closest planned stop (T1 / T2 / C)	-1.6915	-4.2910**	-7.5302	13.4442
	(1.6227)	(1.9671)	(5.7113)	(30.7939)
Distance to closest built stop sq		-0.1001	0.2765	0.1611
		(0.0701)	(0.1653)	(0.2788)
Distance to closest planned stop sq		0.7495**	1.1693	-0.1085
		(0.3479)	(0.7881)	(3.6899)
Post			-33.7279***	0.0000
			(7.0478)	(.)
Distance to closest built stop (T1) x post			7.4940***	7.4238***
			(1.9206)	(2.3564)
Distance to closest built stop sq x post			-0.3767***	-0.3305**
			(0.1230)	(0.1495)
Distance to closest planned stop x post			3.2391	-11.5433
			(5.2140)	(25.9114)
Distance to closest planned stop sq x post			-0.4197	0.9307
			(0.7631)	(3.1278)
Observations	362	362	710	712
Donut FE	No	No	No	Yes
Specification	XS	XS	Panel	Panel

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 9 shows that in our balanced sample, distance to the closest built stop strongly predicts use of the BRT for commuting. For every kilometer further from a mass transit stop, the probability of commuting on the transit line decreases by 0.1 percentage points. The sample mean use is 1%, so this is substantial.

Since the BRT took over lanes in some areas of the city, some have voiced concern about additional congestion faced by commuters on private modes. The effects of a BRT are ambiguous, because it may

shift some commuters into public transport, reducing congestion, but take lanes from private transport, increasing congestion. This has been a major issue in some settings, such as Delhi. However, in the case of Lahore, large sections of the BRT were built on overhead flyover, reducing the lane space required. We repeat our main estimates for the subset of individuals using private modes. These estimates should be taken with caution as they are subject to concerns of sample selection, since the mass transit treatment causes switching out of private transport. However, we find that the BRT reduced commute times reported by these individuals as well, suggestive of a reduction in congestion (table available on request).

Official administrative data indicate that riders board from all parts of the line, but the heaviest traffic is at the endpoints (Figure 8). In addition, over half the riders travel on some other mode to reach the station and then change on to the Green Line (Figure 9). About 80% of riders who walk to the station walk for 15 minutes or less to the station, suggesting a distance of under a mile given typical walking speed of 3 miles per hour. However, about 30% of those who come by another vehicle traveled for more than half an hour to the station, suggesting that mass transit may have affected commute patterns for a larger catchment area than in the literature from the US. This is consistent with the high levels of congestion in Lahore; since these give mass transit a greater speed advantage over private vehicles, the catchment area in which it is optimal to take another mode to the mass transit line is larger (Baum-Snow and Kahn, 2000). However, note that our IV specification effectively addresses any use of the transit in zones selected for the control group.

1.3.2.2.2. Mass transit caused commuters to switch to public transport

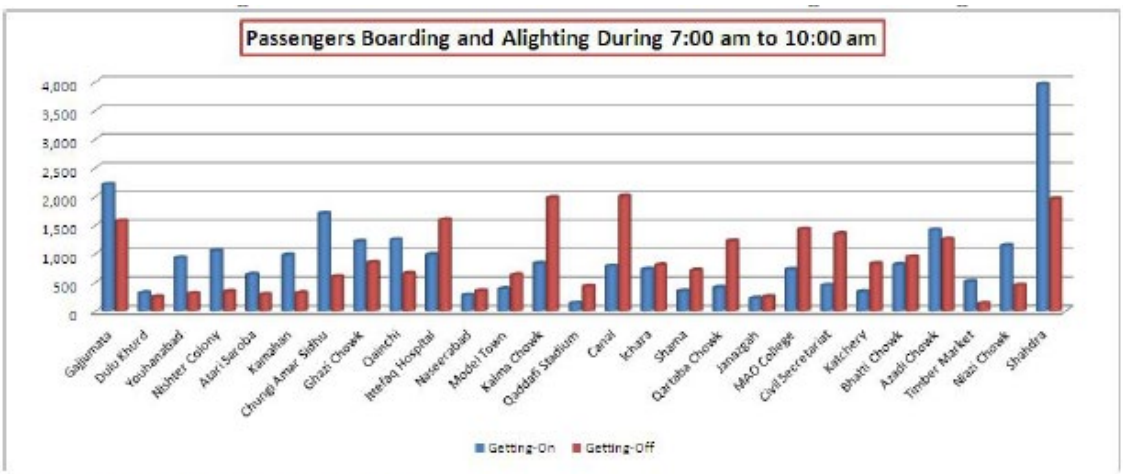
The targeting of public transport towards these higher-income and more educated populations is important because these individuals are the most likely to use private vehicles. This suggests a greater potential for mass transit to induce switching from private to public transit.

Figure 10 shows the previous modes used by riders in our BRT rider survey who report they took the same trip before the mass transit line was built. Strikingly, 40% of the riders switched from using only private transport to public transport. The most common modes they report switching from are rickshaws and motorbikes, followed by cars. The respondents from the highest education brackets are more likely to report switching from a private mode (Figure 11).

Table 10 shows the causal estimates of public transport commuting on our comparable treated and control areas. Here the dependent variable is any use of public transport in the regular daily commute. This is defined as 1 for those who use public modes or a mixture of public and private modes (for example, taking a motorcycle to the mass transit station), and 0 for those who do not commute. The estimates imply that for every 10 minute improvement in public transport access (reduction in time it takes to reach a central point by public transport), the proportion of all residents who commute by public transport to work increases by 0.1-0.4 percentage points, an increase of 5-20% from the baseline mean of 2% of all residents. Table 10 shows the equivalent estimates from a binary treatment specification.

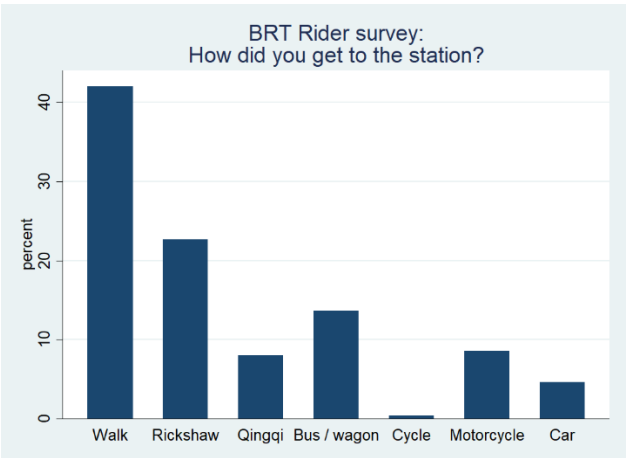
We use the 2010 baseline data to get a total estimate based on extrapolating our estimates to all areas of the city, based on their access to the Green Line. Using this data, we generate predicted values for the change in use of public transport based on the reduced form version of our main estimates from the 2015 data (regressing public transport commuting directly on distance from the BRT stops and distance squared), and assuming zero effect beyond 10km from any stop. This calculation suggests that approximately 35,000 commuters would have switched from private to public transport across the city, assuming similar marginal effects of distance to transit in areas we did not sample. This is in the same order of magnitude as the descriptive statistics from the rider survey, which indicate that 40% of the BRT's riders who took the same trip in the past used private modes; since there are 200,000 riders and about 70% took the same trip in the past, this suggests approximately 56,000 switchers.

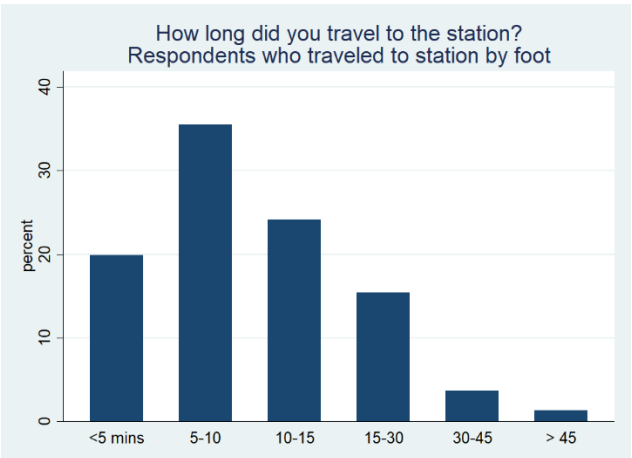
Figure 8: Administrative reports of riders boarding and leaving BRT mass transit



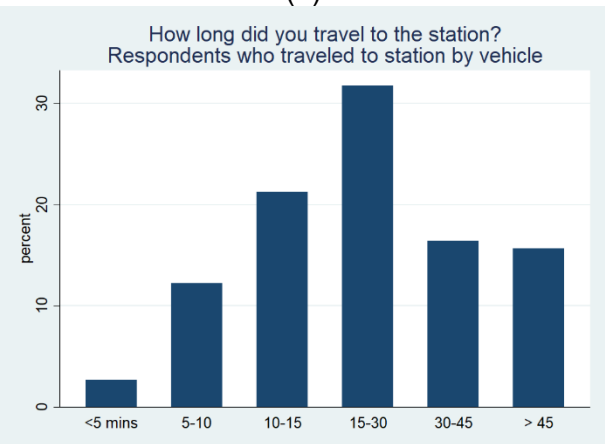
Source: Punjab Mass Transit Authority

Figure 9: Rider survey: reported travel to BRT mass transit station



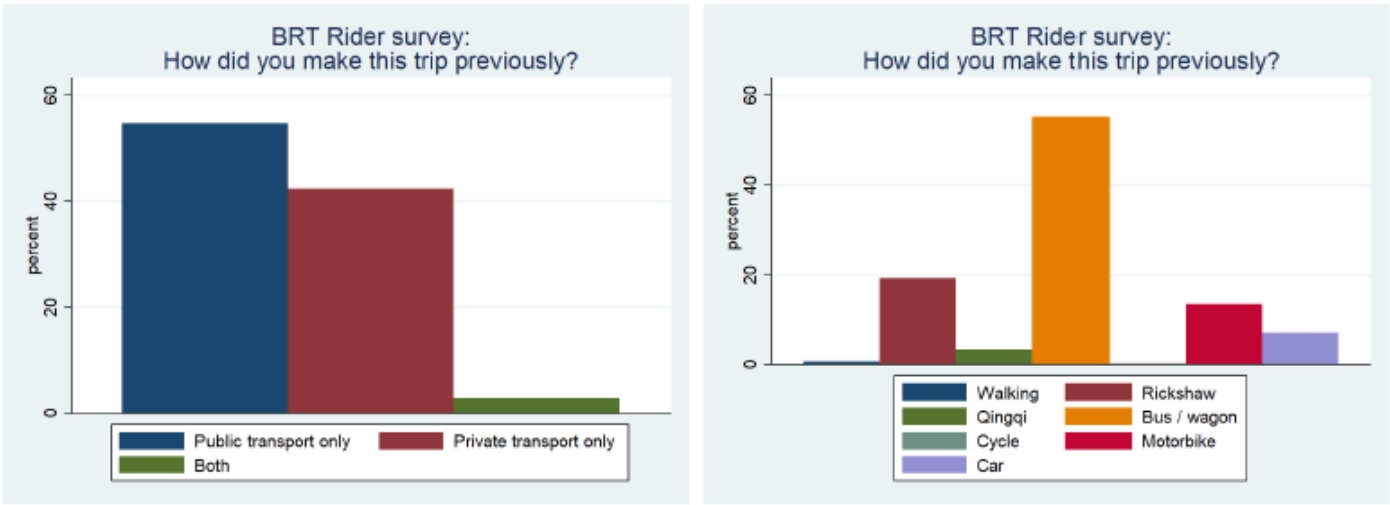


(a) (b)


How long did you travel to the station?
Respondents who traveled to station by vehicle
percent
0
10
20
30
<5 mins
5-10
10-15
15-30
30-45
> 45

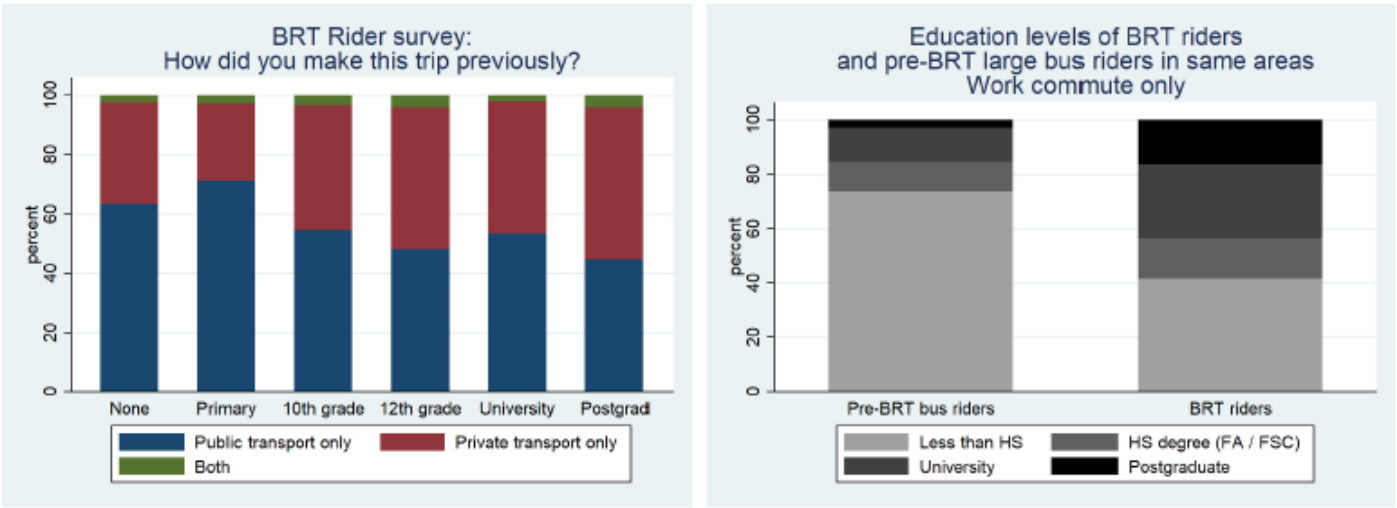
(c)

Figure 10: **Rider survey: previous mode for same trip now taken on BRT mass transit**



(a) (b)

Figure 11: Shift of educated riders to public transport



(a) (b)

Table 7: Impact of transit on commuting by public transport - binary treatment variable

	(1)	(2)
	Commutes by public transport	
Treatment area (T1 - near built stop)	0.0034	0.0027
	(0.0029)	(0.0020)
Treatment area x post	0.0035*	0.0036*
	(0.0019)	(0.0019)
Observations	67230	66436
Additional control variables	No	Yes
Donut FE	Yes	Yes
Geographic sample	T1 T2 C	T1 T2 C
Sample mean pre	0.0200	0.0200

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 8: Impact of transit on probability of working outside the home

	Works outside the home				
Time to access central Lahore by public transport	0.0002	0.0001	0.0001	0.0001	0.0001
	(0.0003)	(0.0003)	(0.0001)	(0.0002)	(0.0002)
Observations	33468	33082	65661	53371	45200
Additional control variables	No	No	No	No	No
Donut FE	No	No	No	No	No
Geographic sample	Full	Full	Full	T1 C	T1 T2
Specification	XS	XS	Panel	Panel	Panel
Hansen's J p-value	0.6559	0.7285	0.5872	0.1643	0.2310
First-stage F-stat	11.8862	18.1658	26.8399	13.0187	25.6594
Sample mean pre	0.2600	0.2600	0.2400	0.2400	0.2500

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

A switch to public transport could imply that commuters have switched from non-motorized modes such as walking or cycling to riding transit. Given that walking is the most common commute mode, this is a possibility in Lahore. While this would lead to time savings for commuters, such a switch would make the environmental impact of the mass transit ambiguous. However, we do not see a significant impact on use of motorized modes for commute (Table 11)[8].

1.3.2.2.3. Mass transit attracted higher status, more educated riders than previous public transport

As Figure 12 showed, more educated households were much more likely to take private modes at baseline. In contrast, the new mass transit line attracts riders with higher education levels. Figure 13(a) shows a comparison of the education levels of mass transit riders from the 2016 rider survey with that of riders of pre-existing buses in the 2010 HIS survey. For comparability, data from the subsample of the 2010 survey living in the zones slated for future mass transit are shown. These two data sources are collected differently, and are thus not fully comparable. Nevertheless, there appears to be a substantial difference in composition: only a quarter of baseline bus riders had a high school (Intermediate) degree or more, whereas 60% of mass transit riders have this level of education. Figure 13(b) shows that in the rider survey, more educated mass transit riders are slightly more likely to have switched from private transport modes.

[8] This is consistent with the fact that the mass transit line is generally considered more convenient for longer distance trips, because riders must climb several flights of stairs to reach the elevated platforms, so a substitution from walking to mass transit is less likely.

Table 13 shows that the causal effect of the mass transit line on the switch to public transport is similar for educated and less educated respondents Taken together, the descriptive and causal results on vehicle owners and educated respondents suggest that the mass transit line, with its high speed, quality and reliability, effectively attracted riders from a broader set of backgrounds, including many who could afford to take convenient, comfortable private commute modes. This indicates a shift towards commute patterns that can be more sustainable in the long run, even as economic growth allows more households to afford private vehicles.

Figure 12: Transport modes at baseline, by education

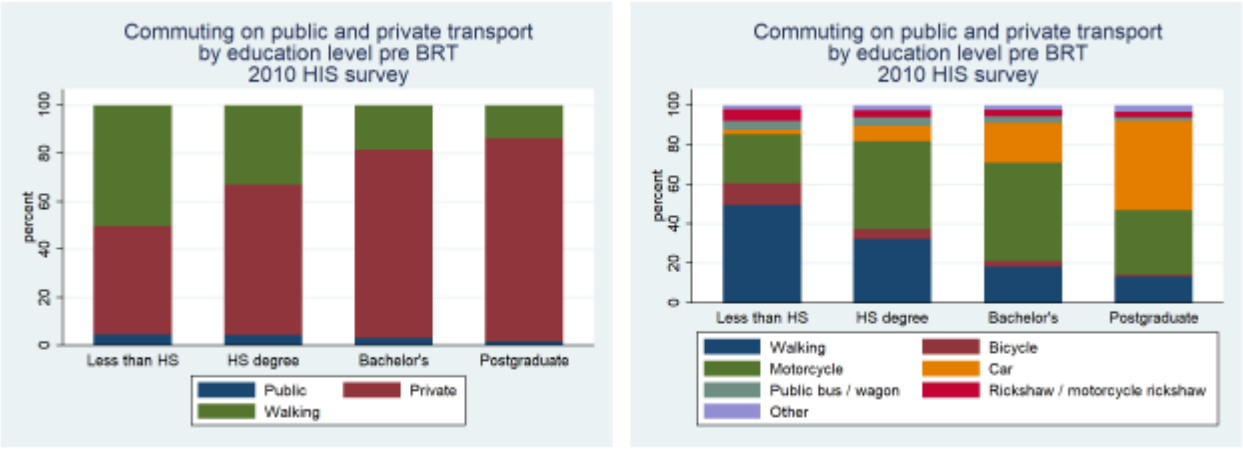
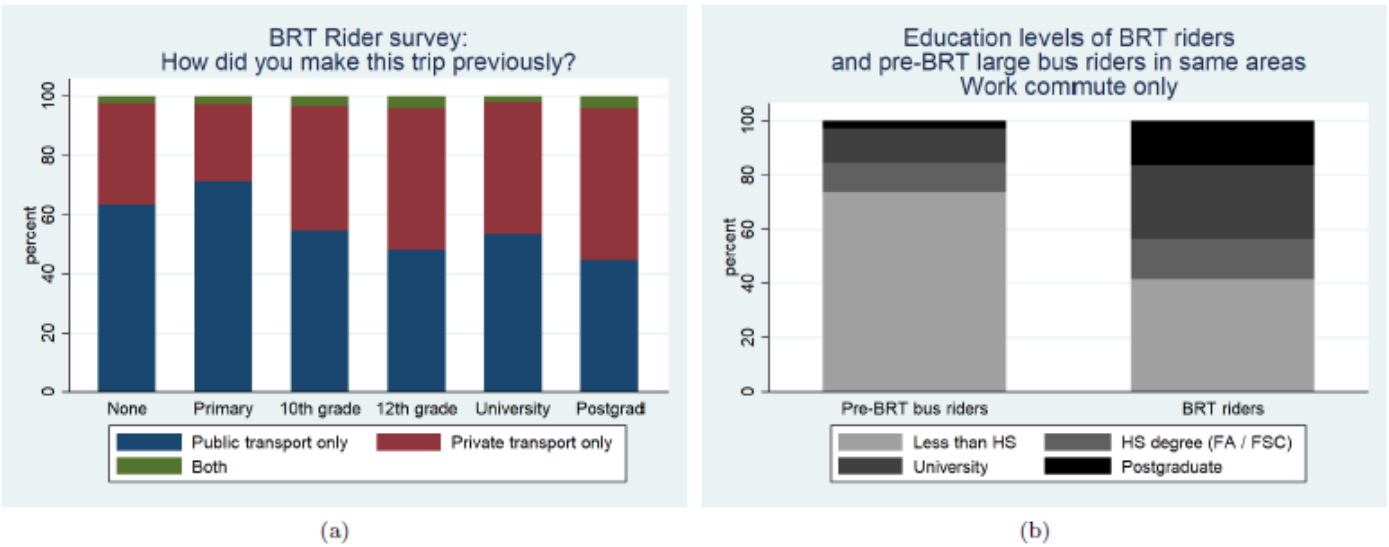


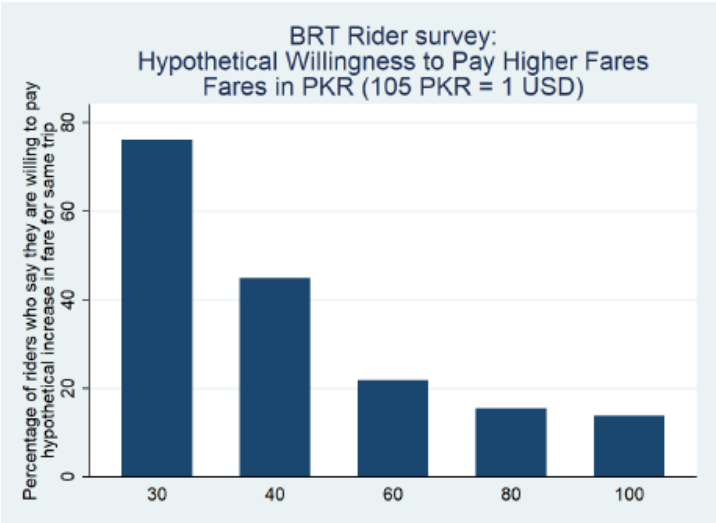
Figure 13: Shift of educated riders to public transport



1.3.2.2.4. Riders state willingness to pay higher than current subsidized fare

To explore the potential for riders to cover more of the cost of the system through higher fares, we asked hypothetical willingness to pay questions in our representative rider survey. Given the value of time savings, the cheap cost of tickets as well as the higher quality, it is not surprising that three-quarters of riders report they would be willing to pay a 50% higher fare for the same trip, and almost half say they are willing to pay double the current fare (Figure 14).

Figure 14: Rider self-reported willingness to pay higher fares for mass transit



1.3.2.2.5. Work to date on structural model

In this component, we develop a structural model of joint work and residential location choice accounting for differential access to transportation options and preference heterogeneity. The household survey records individual demographics, employment and income, and detailed residential location. Importantly, it includes detailed information on trips by household members across the city, which allows us to realistically calculate the commute times for all neighborhood-local market combinations. By estimating the sorting model, we hope to quantify the impact of preference heterogeneity versus exogenous economic and urban infrastructure in determining individual/household location choice. This research will contribute to the urban economics literature in two ways. Firstly, we jointly model work location and commuting choice while allowing heterogeneity in the preference for and availability of transport options, thus making the individual decision process more realistic than models with xed work or residence locations. Secondly, we offer a framework to evaluate the distributional impact of mass transportation projects across the socio-economic spectrum in a developing country. For example, Bus Rapid Transit (BRT) systems in developing countries, such as TransMilenio in Colombia and MyCiTi in South Africa, have reduced the time and monetary cost of commuting and can lead to changes in residence and work locations. In equilibrium, wages in local labor markets will adjust to balance labor supply and demand; neighborhood living costs will adjust to reflect the provision of local public goods and amenities. The impacts of BRT systems are likely to differ for individuals across the socio-economic spectrum through heterogeneity in preferences, employment opportunities, and access to transportation. Understanding these impacts will shed light on the welfare consequences of large-scale transportation projects and inform policy makers. Please refer to Appendix B for the working paper by Chuhang Yin which discusses this in more detail.

This analysis builds on three branches of literature in urban economics and industrial organization. Firstly, it extends the literature on the mismatch between jobs and housing to a developing country context (Cervero [1989], Raphael and Stoll [2002]). Secondly, it uses a sorting framework that is common in the urban segregation and environmental justice literature (Bayer et al. [2009], Depro et al. [2015]). Lastly, it augments a growing literature in urban economics that investigates the impact of transportation networks on the growth and spatial distribution of economic activities in cities (Baker et al. [2005], Baum-Snow and Kahn [2000], Baum-Snow et al. [2016], Gonzalez-Navarro and Turner [2016], Harari [2015]).

1.3.2.2.6. Findings from qualitative sample

Analysis of the qualitative data is still in progress. One key finding which helps to support the identification strategy is that the building of the Metrobus was unanticipated at baseline: the majority of the community respondents interviewed indicated they learned about the building of the line and its route when ground was broken in 2012.

1.3.2.3. Heterogeneity of impacts

Please refer to section 1.3.2.2.

1.4. Cost analysis

The official pre-construction estimate of the capital cost of the BRT mass transit line was 280 million USD, or 11 million USD per kilometer. To date, we have been unable to obtain estimates of the actual incurred costs and running cost from the government. However, if the estimates are accurate, this places Lahore's BRT at $11 million / km, on the high end of bus mass transit, compared to 5-10 million per km for similar systems in Turkey, China, India and Mexico City EMBARQ (2017). These systems are all far less expensive than (higher-capacity) light rail systems, which have capital costs in the range of $40-60 million per km.

The fare is set at 20 rupees (20 US cents) at fare regardless of distance. On a monthly basis, this represents about 7% of the salary of a minimum wage worker. It is also substantially less for a long trip than a standard subsidized bus fare, which ranges up to 45 rupees depending on distance. Based on publicly available budget data and ridership data, triangulated with discussions with transport planners at ADB, we calculate that 75% of the running costs of the system, or 60 cents per person per ride, are subsidized.

1.5. Discussion

1.5.1. Introduction

Please refer to section 1.3.2. which covers this section.

1.5.2. Policy and programme relevance: evidence uptake and use

Please refer to section 1.3.2. which covers this section.

1.5.3. Challenges and lessons

The rollout of data collection for data sources 4-6 has taken more time than originally anticipated, because of the operational complexity of the Job Talash service. This time frame had been discussed with 3IE and we had agreed on a timeframe for the remaining activities. We are confident that the value of the rich labor market and employer data generated by these activities outweighs the additional time taken.

1.6. Conclusions and recommendations

In the developing world, private vehicle ownership is growing rapidly, worsening traffic congestion, increasing carbon emissions, and fostering land-use patterns that may reinforce inequality. To address these challenges, over two hundred cities across Asia, Africa and Latin America have built mass transit systems. Yet most research on urban transport has focused on developed countries. In this study, we collect rich microdata to study the impacts of a new mass transit line in Lahore, Pakistan, using as a comparison group areas which are observably similar at baseline and were slated for transit routes that have not yet been built. We quantify the impact of the line on commuting and use of public modes: access to the new transit line reduced both the time and cost of commuting, led to a 30% increase in public transport use in nearby areas with 35,000 commuters switching from private modes. Second, we examine the incidence of benefits of mass transit. Before the mass transit line, public modes were primarily used by low-income, low-educated commuters; we find that mass transit benefited both low- and middle-income commuters, and they report higher willingness to pay for their trip. This implies that mass transit can be made more financially sustainable through reducing or targeting its running costs.

In ongoing work, which will be submitted with the next report, we estimate the environmental externalities averted due to riders switching from private to public modes test for responses in other markets, including the quantity and price responses in the land market, the location of firm activity, and labor market responses.

In addition, complementary work ongoing in collaboration with Duke Ph.D. student Chuhang Yin explores structural model approaches to work with the data, to help disentangle spatial reorganization of economic activity from total changes in economic activity. The working paper is attached with this report (Appendix B).

Component 1’s evaluation and findings are available in the form of a working paper which is also attached with this report (Appendix A).

Table 9: Takeup of green line mass transit for daily work commute

	(1)	(2)	(3)	(4)
	Dependent variable: Uses green line for daily commute			
Distance to closest built stop (T1)	-0.0011***	-0.0012***	-0.0027***	-0.0027***
	(0.0002)	(0.0002)	(0.0005)	(0.0005)
Distance to closest planned stop (T1 / T2 / C)	0.0010*	0.0002	0.0006	0.0123*
	(0.0005)	(0.0005)	(0.0011)	(0.0074)
Distance to closest built stop sq			0.0001***	0.0001***
			(0.0000)	(0.0000)
Distance to closest planned stop sq			-0.0001	-0.0013
			(0.0002)	(0.0008)
Constant	0.0079***	0.1139**	0.0267	
	(0.0014)	(0.0560)	(0.0552)	
Observations	33620	33226	33226	33226
Sample mean dependent variable		0.0100		
Additional control variables	No	Yes	Yes	Yes
Donut ring FE	No	No	No	Yes

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 10: Impact of transit on commuting by public transport

	Commutes by public transport to work				
Time to access central Lahore by public transport	-0.0004***	-0.0003***	-0.0001*	-0.0001	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	33489	33096	65792	53469	45309
Additional control variables	No	No	No	No	No
Donut FE	No	No	No	No	No
Geographic sample	Full	Full	Full	T1 C	T1 T2
Specification	XS	XS	Panel	Panel	Panel
Hansen's J p-value	0.9674	0.8850	0.0325	0.1078	0.3970
First-stage F-stat	11.8973	18.0913	26.8871	12.9761	25.6513
Sample mean pre	0.0200	0.0200	0.0200	0.0200	0.0200

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 11: Impact of transit on commuting by motorized vehicle

	Commutes to work by motorized vehicle				
Time to access central Lahore by public transport	0.0003	0.0000	0.0001	0.0002	0.0001
	(0.0003)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
Observations	33489	33096	65792	53469	45309
Additional control variables	No	No	No	No	No
Donut FE	No	No	No	No	No
Geographic sample	Full	Full	Full	T1 C	T1 T2
Specification	XS	XS	Panel	Panel	Panel
Hansen's J p-value	0.0055	0.0409	0.3276	0.5273	0.0297
First-stage F-stat	11.8973	18.0913	26.8871	12.9761	25.6513
Sample mean pre	0.1800	0.1800	0.1700	0.1600	0.1700

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 12: Impact of transit on vehicle ownership

	Motorcycles owned				
Time to access central Lahore by public transport	0.0046*	0.0010	0.0005	0.0002	0.0002
	(0.0024)	(0.0014)	(0.0007)	(0.0013)	(0.0007)
Observations	8104	8021	15954	12826	10990
Additional control variables	No	No	No	No	No
Donut FE	No	No	No	No	No
Geographic sample	Full	Full	Full	T1 C	T1 T2
Specification	XS	XS	Panel	Panel	Panel
Hansen's J p-value	0.0765	0.9156	0.1806	0.3588	0.6076
First-stage F-stat	11.2628	16.5646	25.8871	12.1251	23.4094
Sample mean pre	0.9700	0.9700	0.9100	0.8900	0.8700

Standard errors in parentheses clustered by zone. * p<.1, ** p<.05, *** p<.01

Table 13: Impact of transit on commuting by public transport: by education

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: commutes by public transport				
	Sample: high ed (high school +)				
Time to access central Lahore by public transport	-0.0005***	-0.0005***	-0.0001*	-0.0002	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Observations	16295	16295	32478	25867	21761
Hansen's J p-value	0.1997	0.1866	0.1486	0.1461	0.3103
First-stage F-stat	9.9511	13.1667	27.6872	13.0050	24.1983
	Sample: low ed (< high school)				
Time to access central Lahore by public transport	-0.0003***	-0.0002**	-0.0001	0.0001	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	17194	16801	33314	27602	23548
Subsample					
Donut FE	No	Yes	Yes	Yes	Yes
Gegraphic sample	Full	Full	Full	T1 T2	T1 C
Specification	XS	XS	Panel	Panel	Panel
Hansen's J p-value	0.0874	0.0218	0.0942	0.1599	0.7420
First-stage F-stat	13.7745	22.9514	24.7508	11.9665	26.4202

2. Component 2: Transport to Work RCT

2.1. Intervention

2.1.1. Description

Component 2 uses a randomized control trial to study the impact of a transport to work intervention on men, women, and the differential impact of women's-only transport. It will study the impacts of a pilot door-to-door pick-and-drop service which takes individuals from home to work every day at fixed times on a monthly subscription basis.

Pick-and-drop is practiced by some larger employers (Figure 15), but small employers usually do not do so due to economies of scale and coordination costs. Employers may be stuck in a low equilibrium in which any individual does not hire women who would require transport because providing it for a few employees would be prohibitive, but if several neighboring firms hired women the costs per user would be sustainable. The intervention will help to solve the coordination problem between employers by providing transport and subsidizing empty seats for a duration of approximately one year, with the aim of moving firms into an equilibrium with more female employees and thus making the service financially self-sustaining in the long term.

Information about the transport invention is conveyed through a call center-based employment assistance service, Job Talash, which was developed by the researchers. Job Talash is not an intervention but acts as a unique measurement tool for labor market supply and demand side outcomes associated with this RCT. It connects respondents of the household survey who express job interest at baseline to employers in the employer survey that have job vacancies. Job Talash is described in more detail in section 2.2.4.1.

Figure 15: Only a few larger employers provide transport

The service could be provided either by a shared van or by ride-hailing. We explored partnerships with ride-hailing companies as a potential option but decided against them for two reasons: first, many women in our sample do not have their own phone, let alone a smartphone. Overall, 46% of the women who expressed interest in Job Talash at the survey recruitment stage share their phone number with another adult household

member. Second, the women in our pilot exercises expressed a strong preference for having a consistent driver whom they could trust, which the ride-hailing companies were not able to provide. In addition, the ride-hailing companies in Pakistan do not yet offer pooling, which would be essential to bring the long-term cost of the service to an affordable level for this population. As a result, we ultimately determined the optimal solution would be to implement the intervention in partnership with private transporter IS Transport, who provide pick-and-drop services to a number of individual employers. A shared van is used (Figure 16); due to the subscription based nature of the service, there is a semi-constant pool of riders on the vehicle, which may enhance the level of comfort that female riders may have with the service. Through the project, the operator is subsidized for a limited period of time to help overcome the coordination costs involved in arranging a pick-and-drop that serves a whole cluster of smaller employers.

Figure 16: Pilot transport service

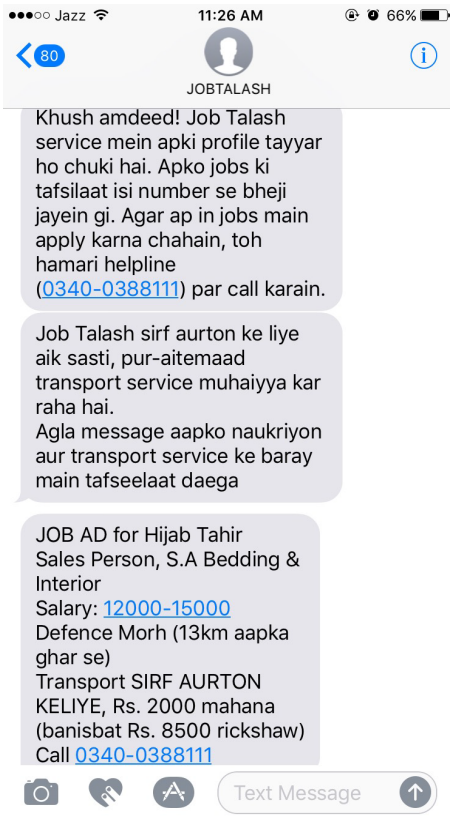
Source: Photograph of transport vehicle used in research pilot. 2015. Centre for Economic Research for Pakistan.

This service is offered in addition to existing public and private transport services that are available in the status quo. The findings of the first stage of the project, including piloting, show strong interest in the service, because it compares favorably with other transport choices:

- Compared to standard public transport services (bus and wagon), the service will be much quicker, more reliable in timing, less crowded, and for women safer and more socially acceptable (women are often harassed on public transport vehicles; despite having separate sections in principle, these are often poorly enforced);
- Compared to rickshaws, the service will be cheaper and perceived as more socially acceptable and safer than traveling alone or in a small group with a male rickshaw driver;
- For women, the pick-and-drop is socially acceptable, while solo travel on bicycles or motorcycles, commonly used by men, are considered completely taboo for women.

Job candidates are informed about the availability of the transport service as an offer available for the named candidate and job opportunity specifically. The information is shared through the Job Talash SMS as well as the phone script used by the Job Talash call center (Figure 17). This allows for precision in offering the treatment: we ensure that treated individuals are aware of exactly which jobs the service can take them to, and minimize information spillovers or the risk of takeup by the control group.

Figure 17: Transport intervention offer through Job Talash



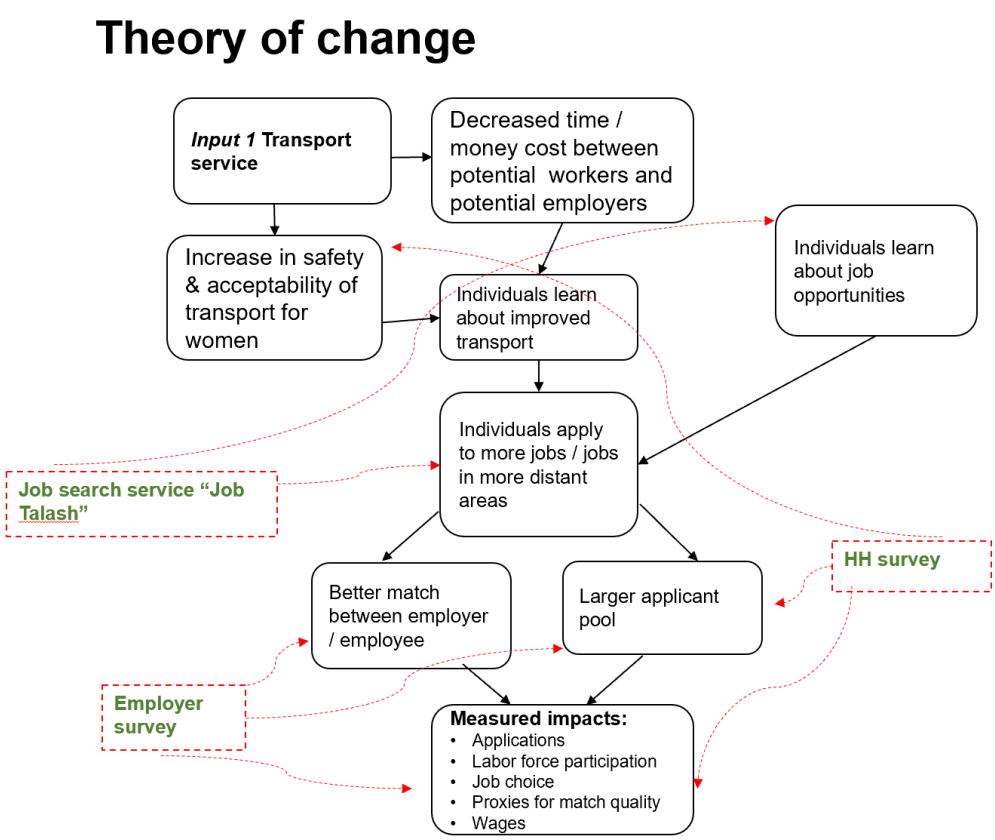
Source: Screenshot of SMS containing job and transport information to Job Talash subscriber. 2018. Centre for Economic Research for Pakistan.

We envision that this service could be implemented at scale by a private operator or as part of a public-private partnership; whether it is feasible will depend on the ridership and revenues of the service over the course of the study. The cross-randomization of fare levels helps us speak to this. We will be conducting an analysis towards the end of the study which will assess whether and how the intervention should be adapted or taken forward based on the findings of the RCT, and use this as a basis to return to relevant stakeholders with whom we have engaged (including Careem, a ride hailing service, Lahore Transport Company, Punjab Metropolitan Transport Authority and the Punjab Commission on the Status of Women) to discuss potential options for scale up or adaptation of existing services in light of the findings.

2.1.2. Theory of Change

The theory of change for Component 2 is explained in Figure 18

Figure 18: Theory of change: Transport to work RCT



2.1.3. Intervention monitoring plan

In order to ensure data quality, we hire and train Quality Assurance Officers for all data collection teams. These staff members are tasked with conducting a number of activities to monitor the quality of the data being collected and rectify any issues. These activities include spot checks, listening in to audio recordings of surveys, comparing audio recordings with the data input in survey instruments, as well as accompanying enumerators while they conduct surveys. For the transport intervention, we plan to take the quality assurance measures that we took during the pilots of the intervention. A Field Coordinator at CERP will work directly with a point person at the private transport vendor to monitor all aspects of the transport intervention and its quality, including on-time arrival and correct routing (using vehicle trackers). We will also poll users periodically to check for their satisfaction with the service and elicit any complaints, using the Job Talash call center. In particular, we train all drivers on how to deal with harassment and expectations of their own behavior, and will monitor for any such complaints closely.

2.2. Evaluation questions, design, methods, sampling and data collection

2.2.1. Primary and secondary evaluation questions

This component aim to answer the following questions:

1. How do investments in urban transit affect labor markets?

2. What kinds of areas are likely to benefit most from these investments? Can they help to integrate periurban and other marginalized areas of the city?
3. How do these investments affect men and women differently? How does women's-only transport affect women differently from mixed-gender transport?

2.2.2. Evaluation design and methods

The intervention takes the form of a door-to-door pick and drop transport service which takes individuals from home to work and back on a monthly subscription basis. This is commonly practiced by larger employers, but small employers usually do not do so due to economies of scale and coordination costs. Employers may be stuck in a low equilibrium in which any individual does not hire women who would require transport because providing it for a few employees would be prohibitive, but if several neighboring firms hired women the costs per user would be sustainable. The intervention will help to solve the coordination problem between employers by providing transport and subsidizing empty seats for a duration of approximately one year, with the aim of moving firms into an equilibrium with more female employees and thus making the service financially self-sustaining by the end of the RCT.

The service could be provided either by a shared van or by ride-hailing. We explored partnerships with ride-hailing companies as a potential option but decided against them for two reasons: first, many women in our sample do not have their own phone, let alone a smartphone. Overall, 46% of the women who expressed interest in Job Talash at the survey recruitment stage share their phone number with another adult household member. Second, the women in our pilot exercises expressed a strong preference for having a consistent driver whom they could trust, which the ride-hailing companies were not able to provide. In addition, the ride-hailing companies in Pakistan do not yet offer pooling, which would be essential to bring the long-term cost of the service to an affordable level for this population. As a result, we ultimately determined the optimal solution would be to implement the intervention in partnership with private transporter IS Transport, who provide pick-and-drop services to a number of individual employers. Due to the subscription based nature of the service, there is a semi-constant pool of riders on the vehicle, which may enhance the level of comfort that female riders may have with the service. Through the project, the operator is subsidized for a limited period of time to help overcome the coordination costs involved in arranging a pick-and-drop that serves a whole cluster of smaller employers. This transport service will be implemented by the private transporter in collaboration with CERP.

This service will be offered in addition to existing public and private transport services that are available in the status quo. The findings of the first stage of the project, including piloting, show strong interest in the service, because it compares favorably with other transport choices:

- Compared to standard public transport services (bus and wagon), the service will be much quicker, more reliable in timing, less crowded, and for women safer and more socially acceptable (women are often harassed on public transport vehicles; despite having separate sections in principle, these are often poorly enforced);
- Compared to rickshaws, the service will be cheaper and perceived as more socially acceptable and safer than traveling alone or in a small group with a male rickshaw driver;
- For women, the pick-and-drop is socially acceptable, while solo travel on bicycles or motorcycles, commonly used by men, are considered completely taboo for women.

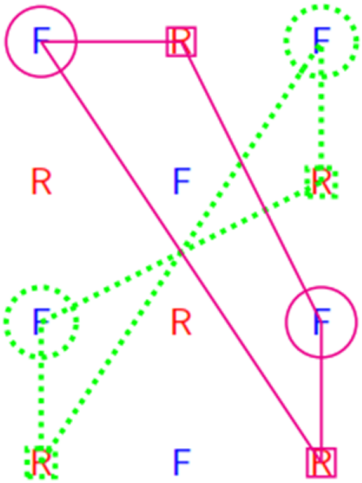
Both jobseekers and firms are randomly divided into four groups, randomized by enumeration block. In one treatment arm, the transport services will be female only in a second treatment arm, they will be mixed gender; and in a third treatment arm, they will be mixed-gender vehicles but offered only to women in that particular

enumeration block (to separate out labor supply effects in the household from effects of the mixed-gender nature to the transport). All jobseekers are connected to all matching jobs through our employment facilitation service called Job Talash; all jobseekers in a given arm are offered transport for all firms in the same treatment arm only. Therefore we have both between- and within-respondent variation in the transport offer. Figure 19 illustrates the design.

Figure 19: RCT residential and firm clusters

Key: F = Firm / employer cluster; R = Residential cluster

Pink lines show connections between T1 areas; green dotted lines show connections between T2 areas. Note that areas in between can be part of the control group without concerns for spillovers, due to the regulated pick-and-drop sign-up feature of the intervention.



The analysis using the employer-side randomization and the employer survey, in conjunction with rich data from Job Talash, will allow us to measure the effect of this intervention on candidate pool size and composition, as well as match quality proxies for employers. This allows us to speak to whether the transport simply replaces a control jobseeker with a treated jobseeker, or actually changes the scope of the labor market and improves match quality.

2.2.2.1. Managing spillovers

The targeted and controlled nature of the pick-and-drop service means that the kind of large, direct spillovers normally expected in a transport intervention (e.g. people in control areas traveling to treatment areas to use the transport) are unlikely. However, to measure possible spillovers we have taken the following steps:

- At baseline, households were invited to nominate other contacts for Job Talash as a way of eliciting their social networks. This will allow us the option of surveying these contacts to test for social spillovers.
- For intervention feasibility, the main randomization takes place by enumeration block, within zones of the city. However, both the firm and household sampling strategy include “full control” zones with only control enumeration blocks.

2.2.3. Ethics

This component of the project was approved by the Duke IRB under protocol number C0441.

- Consent to respond to the survey: For each survey data source, enumerators were carefully trained on a protocol for obtaining respondent consent before proceeding.
- Burden of time taken to respond: All surveys were kept limited in length to reduce the burden on respondents. Jobseekers and firms (which are the respondents to the main instruments in the study) receive the benefits of the Job Talash service for free, and randomly selected participants will receive access to the transport service.
- Protection of personal information: This is achieved through limited access to identifying data and data encryption using BoxCryptor.
- Harassment on service: we expect the enforcement on our service (even mixed gender transport) to be substantially better than the status quo, in which harassment is prevalent.
- Discontinuation of service: depending on takeup and cost effectiveness analysis, we will work with the government and IS transport on potential long-term extension of the treatment. Participants are informed of the duration of the guaranteed service before signing up so they can make an informed decision.

2.2.4. Sampling and data collection

2.2.4.1. Description of Job Talash household survey and signup data

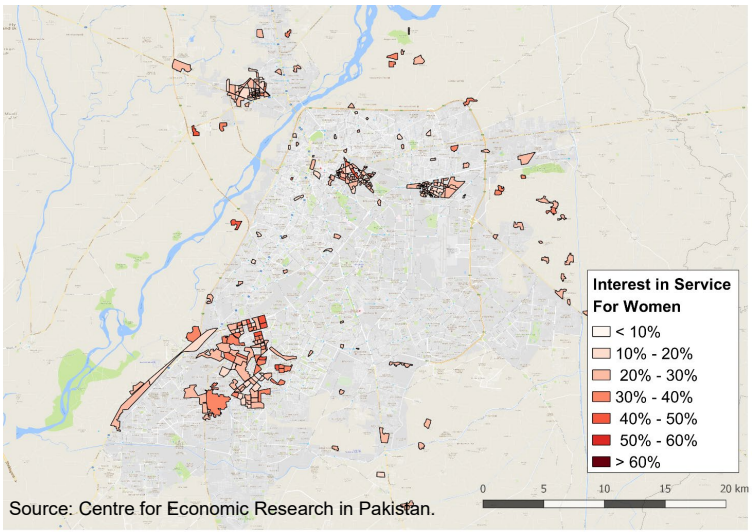
We developed an employment assistance service, Job Talash, which acts as a unique measurement tool for labor market supply and demand side outcomes. The service connects respondents of the household survey who express job interest at baseline to employers in the employer survey that have job vacancies. Job Talash is directly under the researchers' control, which allows for small, fast, continuous experiments which can be adapted at each step based on previous pilots and findings, rather than renegotiation with an implementing partner. In this section, we describe the recruitment and platform in greater detail.

For initial enrolment, we conducted a household survey of a clustered random sample of households across metropolitan Lahore. In each household, a respondent reports a roster of adult household members and basic information on their age, education, and current work status, for a total sample of approximately 150,000 members. For each member (whether currently working or not), the enumerator asks whether he/she was interested in signing up for Job Talash, a job search service, and if so notes contact information for him/her. The enumerator also leaves a flyer with a unique code and a contact number for Job Talash (Figure 20). Individuals from all areas of the urban and peri-urban sample expressed interest (Figure 21 and Figure 22), including men and women of all education levels (Figure 23).

Figure 20: Job Talash flyer distributed during the household survey

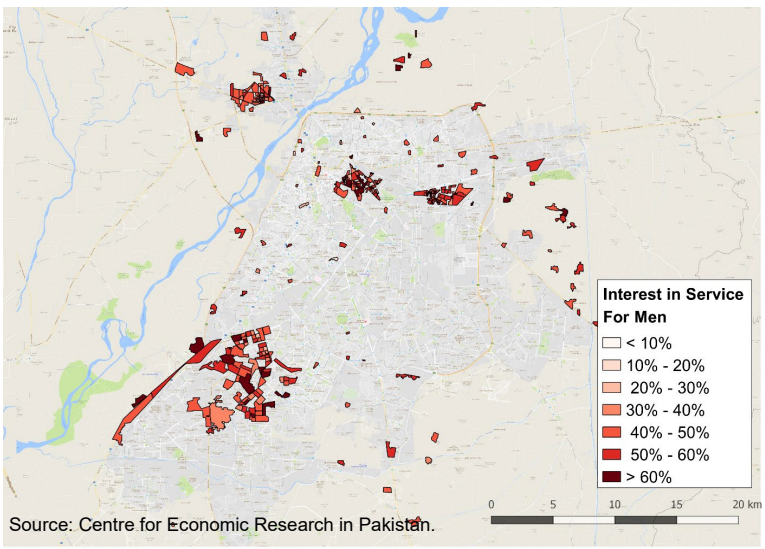
Source: Image of Job Talash flyer given to survey respondents. 2016. Centre for Economic Research for Pakistan.

Figure 21: Interest in Job Talash – Women



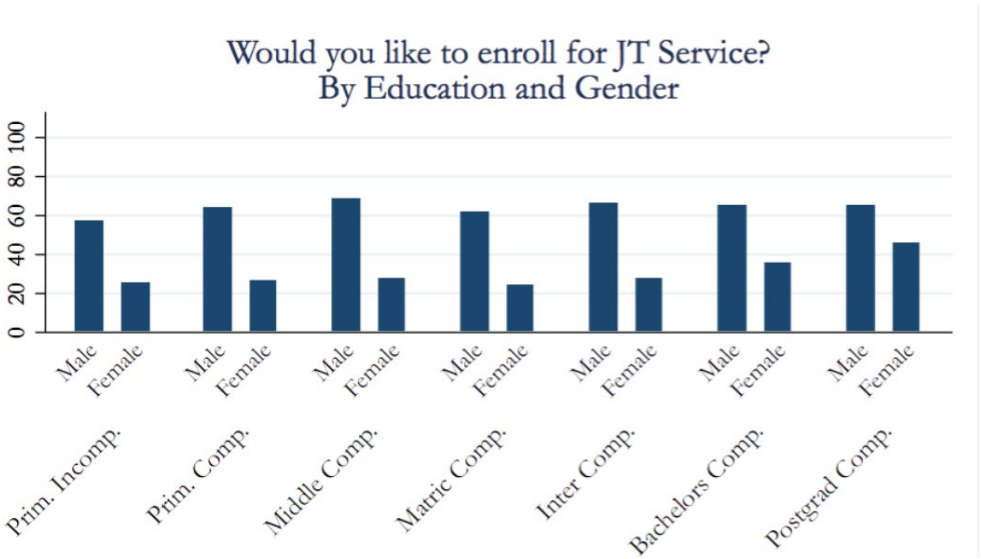
Source: Centre for Economic Research in Pakistan.

Figure 22: Interest in Job Talash -- Men



Source: Centre for Economic Research in Pakistan.

Figure 23: Interest in Job Talash, by education level and gender



Many of these individuals were not interested in working (Figure 24); of those searching, the most common search method was through social networks (Figure 25). This suggests that (a) the platform is likely an important tool to ensure that participants know about jobs farther away that they might access through transport; in the absence of this platform jobseekers might not find out about jobs further from their residential area and thus they might not be able to respond to the transport intervention in the short run; and (b) the interventions on this platform including transport have the potential to increase labor force participation on the extensive margin, as well as intensive margin.

Figure 24: Interest in Job Talash

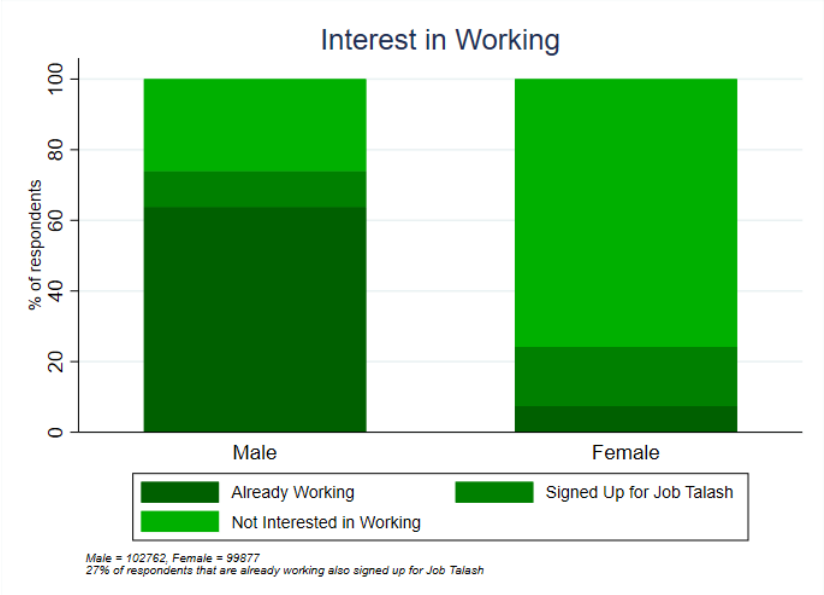
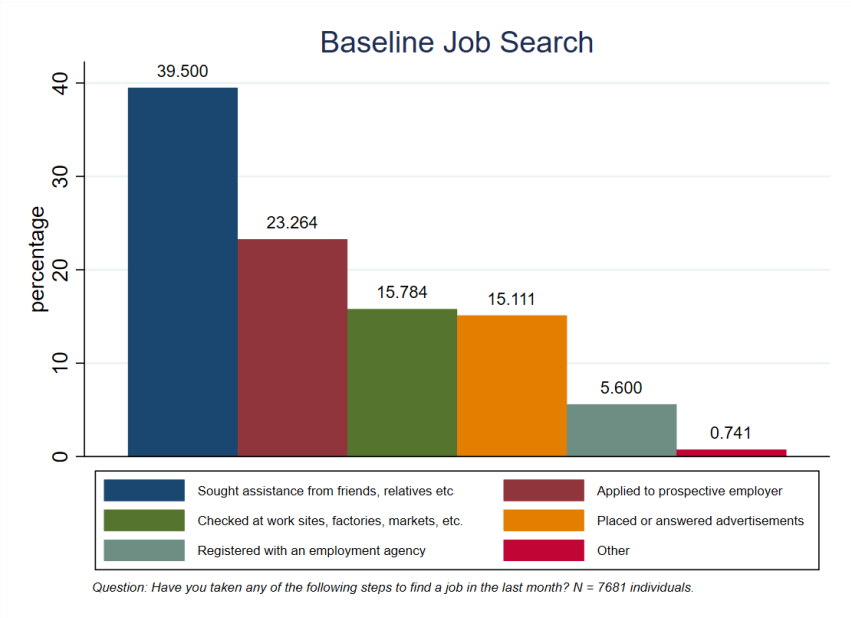


Figure 25: Methods of job search at baseline



The Job Talash call center then called the individuals marked as interested in the household to sign them up. On each call, the Job Talash team verified the individual's interest in the service; this stage yielded a total sample of approximately 10,000 subscribers. For interested respondents, the Job Talash team then signs him / her up as a Job Talash subscriber by gathering more detailed background information about the applicant's education including institutions, specializations, and grades, and full details of work experience and responsibilities, along with current job search activity and preferences for different types of jobs. The Job Talash team then prepares a CV for each subscriber with the information gathered on the call. The CV was sent to the subscriber via WhatsApp or post to confirm accuracy. Once the subscriber is enrolled, Job Talash includes him/her into a pool of potential candidates for job matching.

Our pool of subscribers eligible for matching come from diverse educational backgrounds and have varying degrees of work experience (Figure 26). A greater proportion of our female subscribers have a greater than high school education level compared to our male subscribers (Figure 27). Male subscribers, on average, are more experienced than women: 40% of our female subscribers had no work experience at baseline compared to 20% of men (Figure 28).

Figure 26: Signup rate for Job Talash among surveyed population, by education level

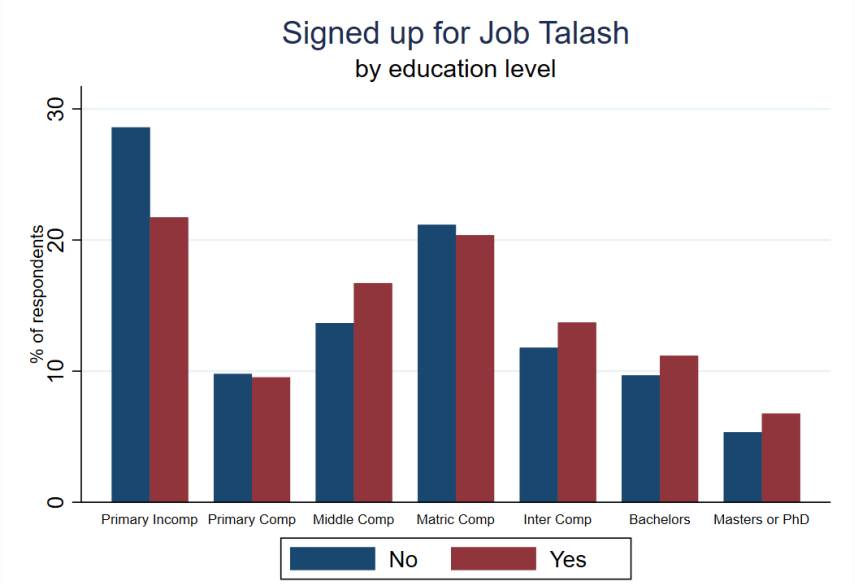


Figure 27: Education level by gender

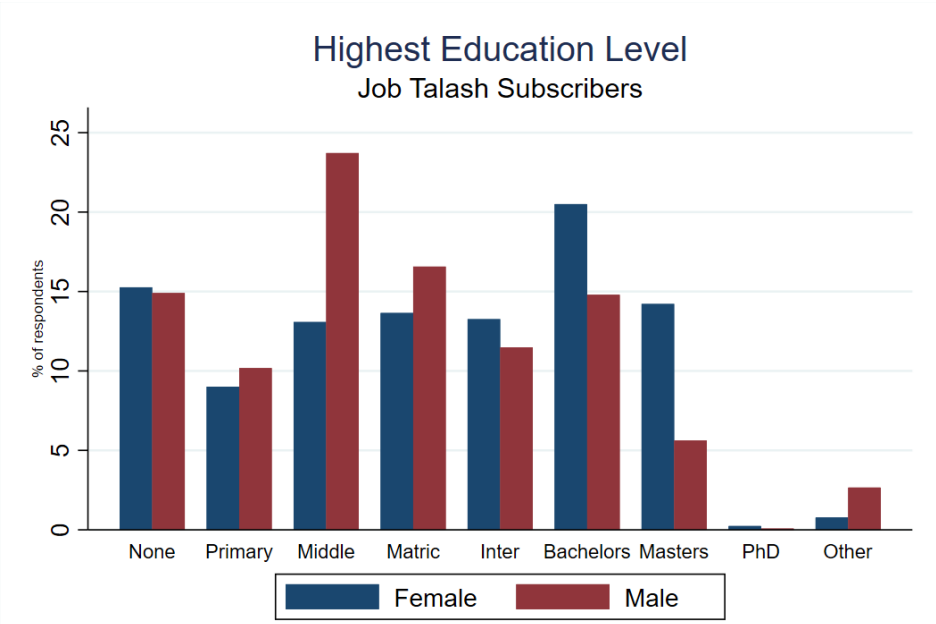
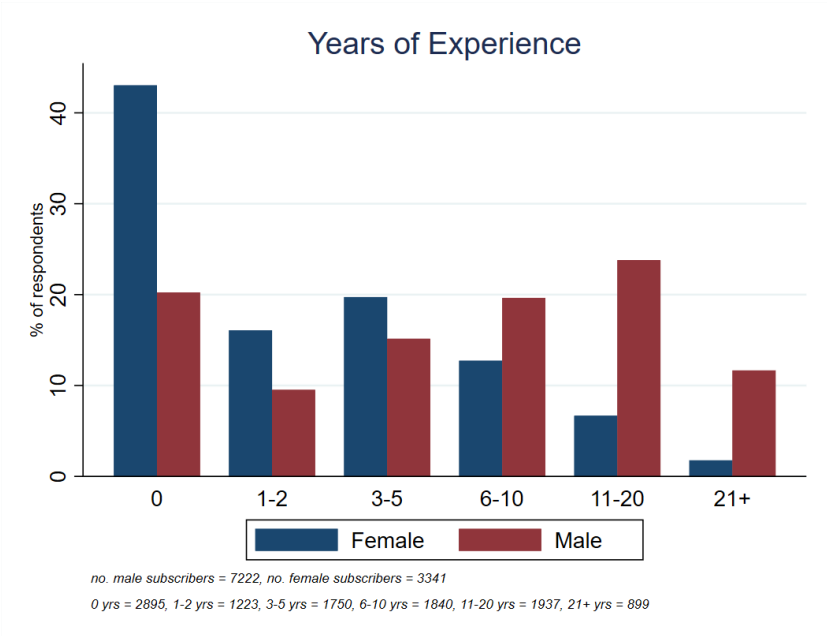


Figure 28: Years of experience, by gender

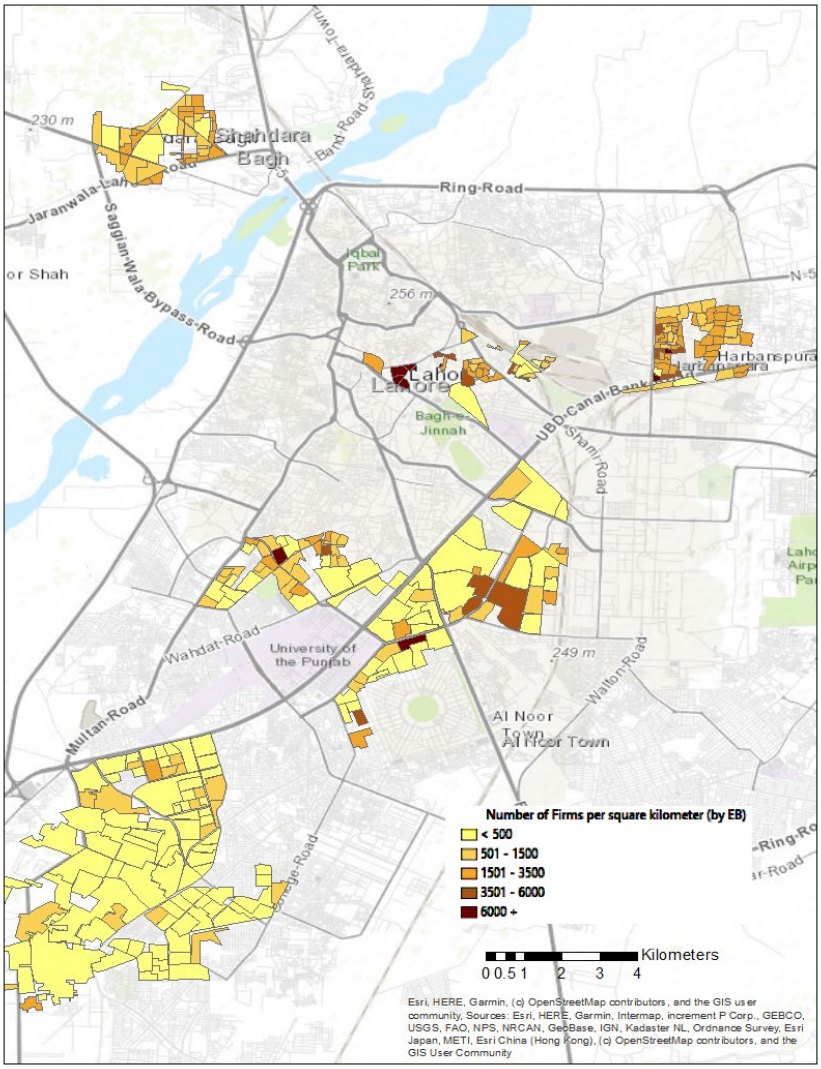


2.2.4.2. Description of Job Talash employer survey

To enrol employers, we again covered a representative sample across the metropolitan area. We subdivided existing administrative zones in this area. We then used a listing of employers we compiled from multiple administrative sources and geocoded to identify the industry composition of each area. We used this to draw a stratified random sample of clusters, ensuring representative coverage of different industries. The sample frame of enumeration blocks used for the employer survey is the same one used for the household survey (described above), but the selection of EBs is independent, so there is little to no overlap between residential and employer EBs in the sample, and a high degree of variation in distance between a jobseeker and employer. Figure 29 and **Error! Reference source not found.** show selected areas of the city where the listed firms in the sample are located and the industry they belong to.

Once jobseekers are matched to job offers, we follow up with firms with a feedback survey. Data is collected before and after interviews are held to know which candidates were called for an interview, how they performed and who was finally hired for the position. If the person hired was not recommended through Job Talash, we ask firms which methods they used to find the candidate, key characteristics (education level, years of work experience, gender). We also collect data on general service satisfaction.

Figure 29: Geographic Distribution of Listed firms



2.3. Findings

2.3.1. Intervention implementation fidelity

Please refer to section 2.5.1. for this topic.

2.3.2. Impact analysis

2.3.2.1. Descriptive statistics and balance table

In this section, we first discuss the statistics related to the household survey of jobseekers, focusing on descriptive statistics related to their use of and preference for transport. Other descriptive statistics related to this sample has either been discussed in the “Sampling and Data Collection” section (2.2.4) of this report or the baseline survey report submitted to 3IE in the past. We then present descriptive statistics from the survey

of employers, describing employers' industries, sizes, recruitment practices and preferences, and the qualitative data collected from employers. Finally, we present the data on the interaction between the jobseekers and employers, i.e. job applications of individual subscribers of Job Talash in response to job ads posted by firms.

2.3.2.1.1. *Statistics related to Jobseekers Sample*

As mentioned in Section 2.2.4, the sample includes both female and male jobseekers with a wide range of educational and work experiences (Figure 23, Figure 26, Figure 27). To better understand perceptions of the safety and acceptability of different modes of transport and the extent to which transport constraints impact job take-up, we asked subscribers about mobility. This part of the report discusses the statistics related to jobseeker mobility.

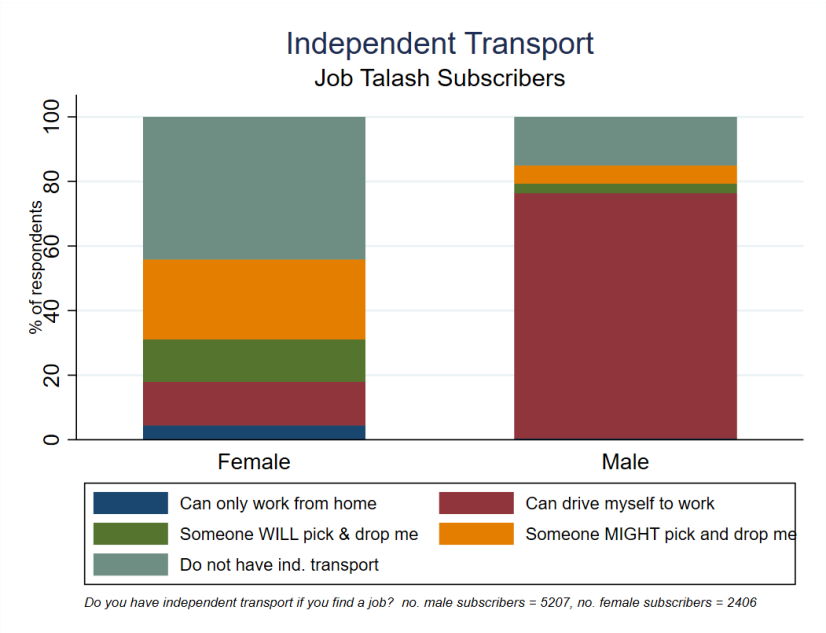
Figure 30 illustrates that women's access to independent transport to work is restricted compared to men. Around 80% of men report that they can drive themselves to work compared to just over 10% of women.

Subscribers across the education spectrum report that they are more likely to take a job when transport is provided (Figure 31) and prefer employer pick and drop to other modes of transport (Figure 32).

When asked specifically about employer pick and drop, subscribers mentioned that it is an important consideration in their decision to take up a job. 80% of women and 60% of men say that employer pick and drop is either extremely important or very important in their job market decisions (

Figure 33).

Figure 30: Access to independent transport to work for Job Talash subscribers, by gender



It is important to note that the survey of jobseekers was preceded by a listing exercise in which we listed approximately 50,000 households in a clustered random sample of households across metropolitan Lahore. We recorded a roster with age, education, and current work status for all adult members, for a total sample of approximately 150,000 adults. For each member (whether currently working or not), the enumerator asked if s/he was interested in signing up for Job Talash. The Job Talash call center then called interested individuals, verified their interest in the service and gathered detailed information on the applicant's education, work experience, job search activity and preferences for different kinds of jobs. Of those who ended up signing up for Job Talash, 50% of male and 60% of female participants were not actively searching for jobs at baseline: this unique approach successfully identified latent jobseekers who may respond to reduced frictions by entering job search, allowing us to speak to search and labor force participation on the extensive margin.

Figure 31: Impact of transport on job take up, by education level

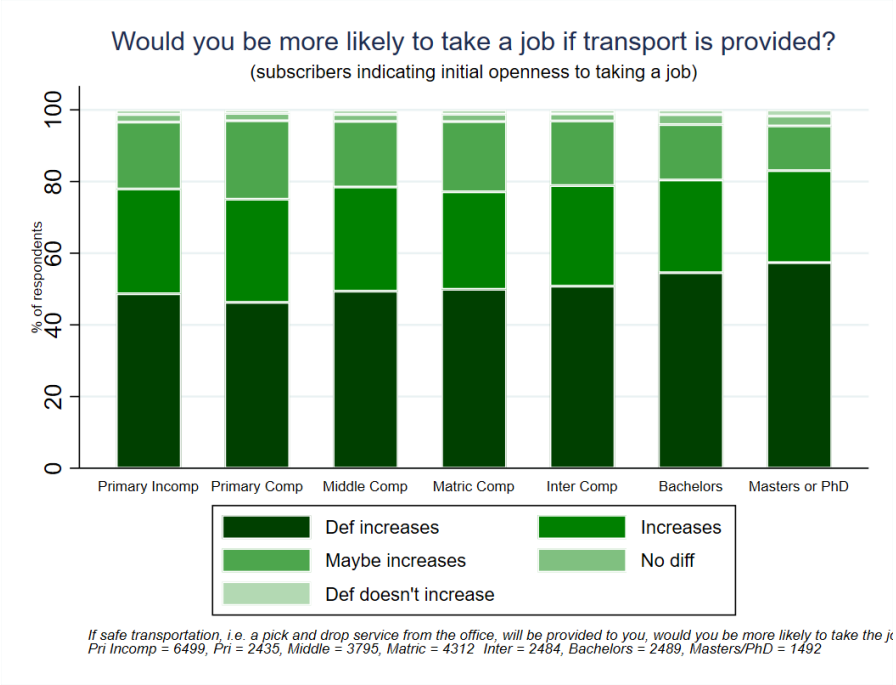


Figure 32: Intended use of transport modes to work

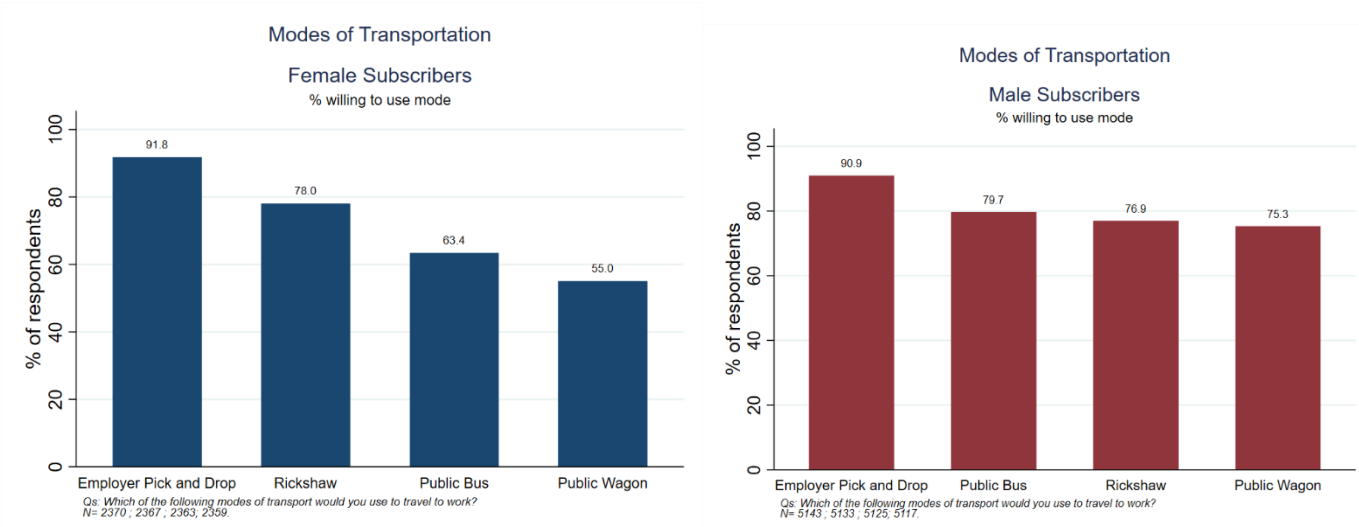
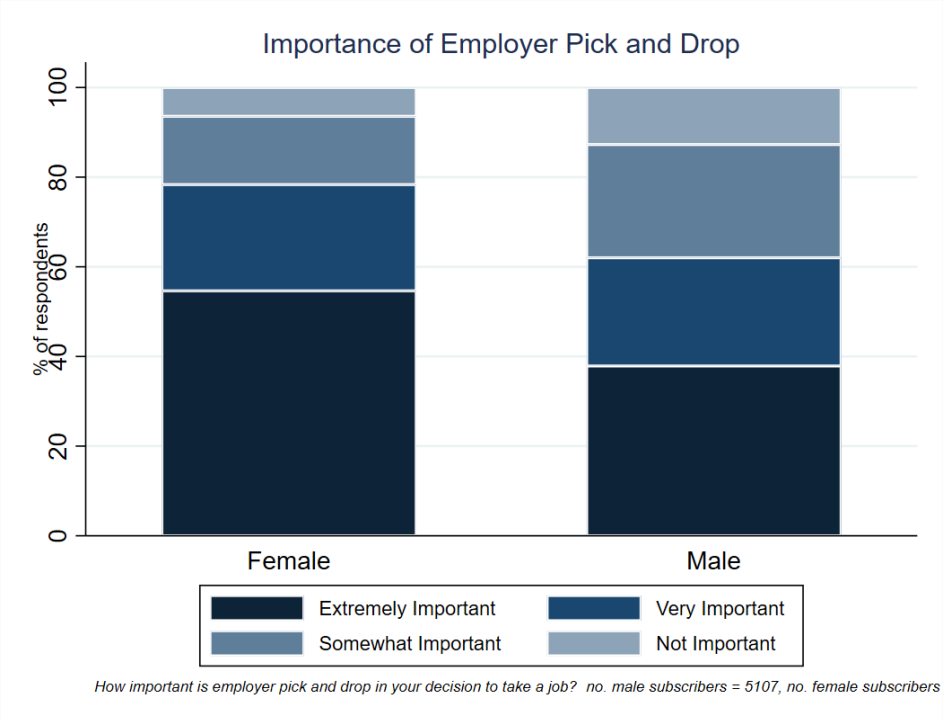


Figure 33: Job Talash subscriber stated importance of employer pick and drop in labor market decisions, by gender



2.3.2.1.2. *Statistics related to Employer Sample*

2.3.2.1.2.1. Description of the quantitative sample

During the employer survey, 10,420 employers were successfully listed. Out of these, 1,038 were eventually found to be permanently closed. When these listed employers were contacted for the survey, the overall response rate for the survey was approximately 23.6%, considering the following three groups of firms:

- Those who signed up for the Job Talash service and provided additional information about the firm through the survey (approximately 10%),
- Those who did not sign up for the Job Talash service but provided additional information about the firm through the survey (approximately 13.6%).

Reasons for unsuccessful attempts include firms' office being closed during the visit by the enumerator, the relevant person not being available for the interview, or a refusal by the respondent to signup for the service and to answer the survey questions.

The employer survey sample includes firms from multiple industries, with 50% of firms identifying their activities as wholesale, retail, and repair trades. Figure 34 shows the most common industry classifications of the firms in the sample and **Error! Reference source not found.** breaks down these classifications by survey respondents and non-respondents.

Figure 34: Industry Classification

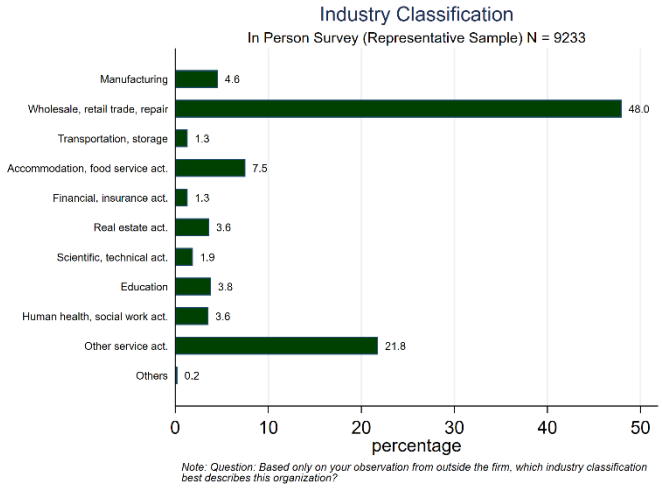
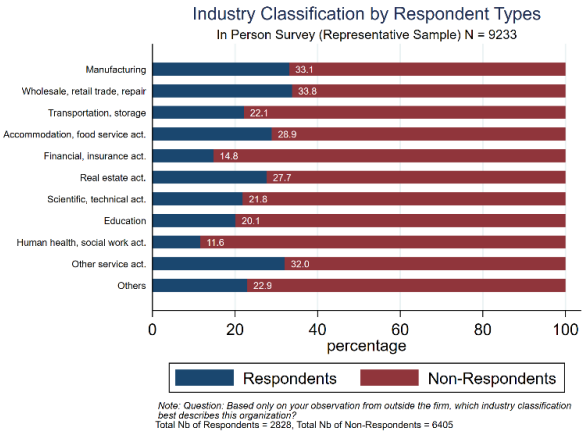


Figure 35: Industry Classification of Respondents and Non-Respondents



Additionally, most firms from the sample are small businesses with space equivalent to 1 room/shop (Figure **36**). Thus, most of the respondents and non-respondents are from small firms (Figure **37**).

Figure 36**: Firm Space**

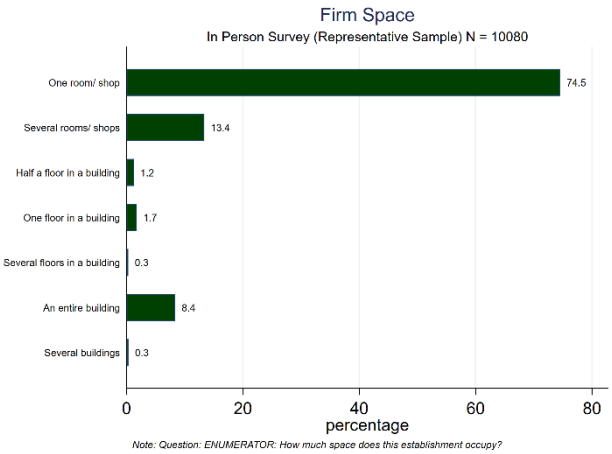
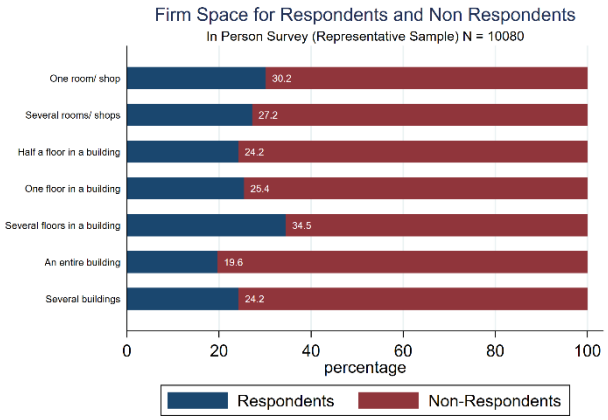


Figure 37**: Firm Space of Respondents and Non-Respondents**



Comparing firms that sign up for Job Talash with those who don't, it is clear that firms with area greater than one room are more likely to sign up (Figure 39). These sign ups come from a variety of sectors, with the percentage of signups from the services sector being higher than the percentage of non-sign ups from the same sectors (Figure 38). The sign up firms also have a higher average turnover for both low education and high education (Figure 40) and employee size (Figure 41).

Figure 38: Industry of Sign ups and Non-sign ups

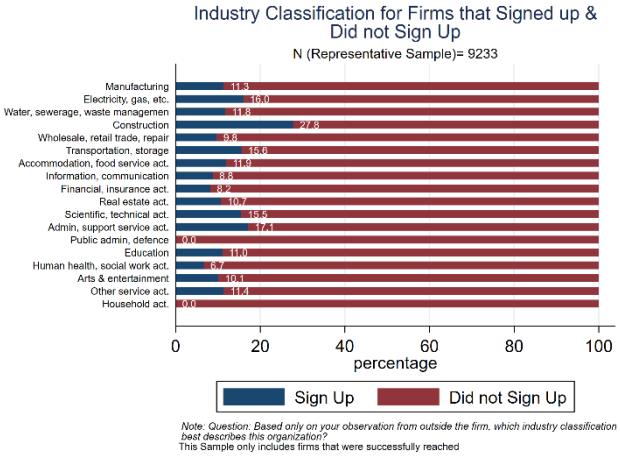


Figure 39: Firm Space of Sign ups and Non-sign ups

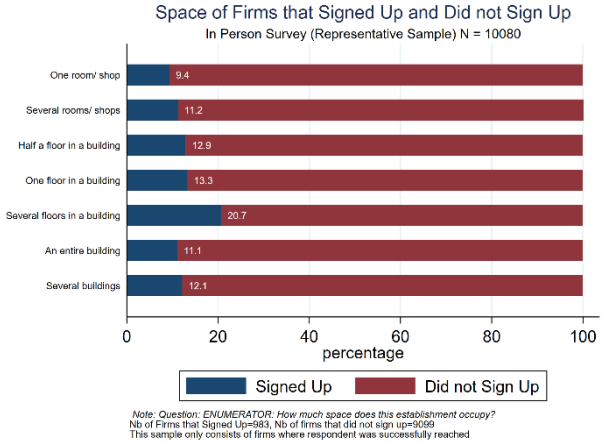


Figure 40: Average turnover for Sign ups and Non-sign ups

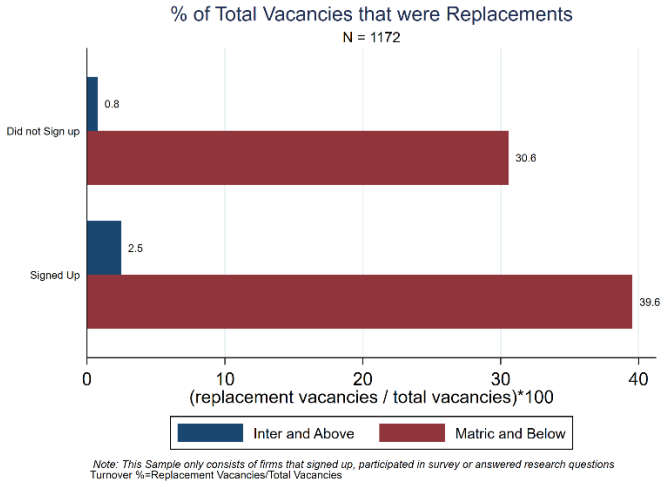
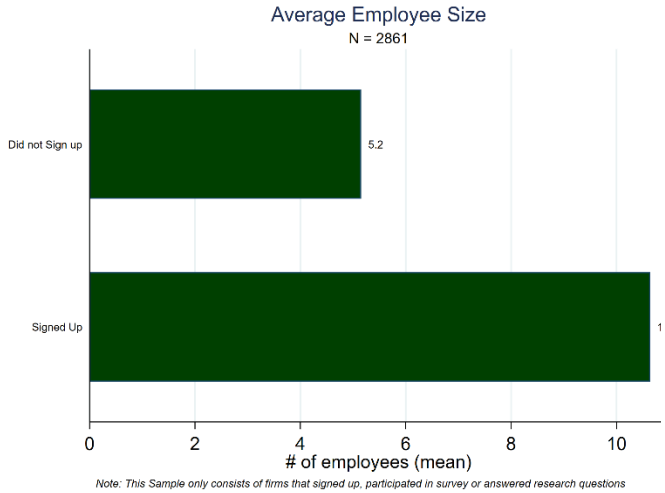


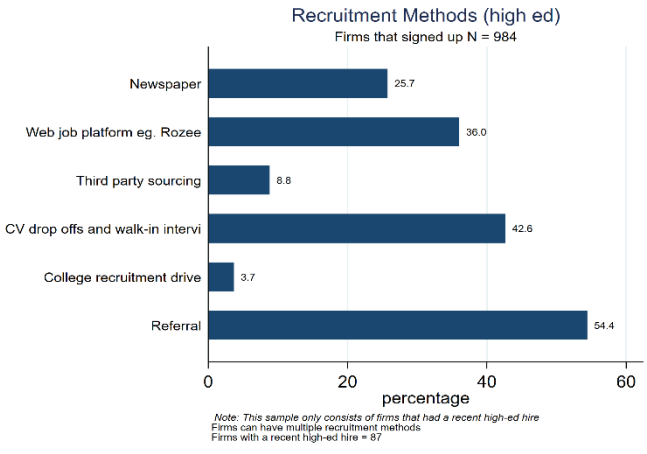
Figure 41: Average Employee Size for Sign up and Non-sign ups



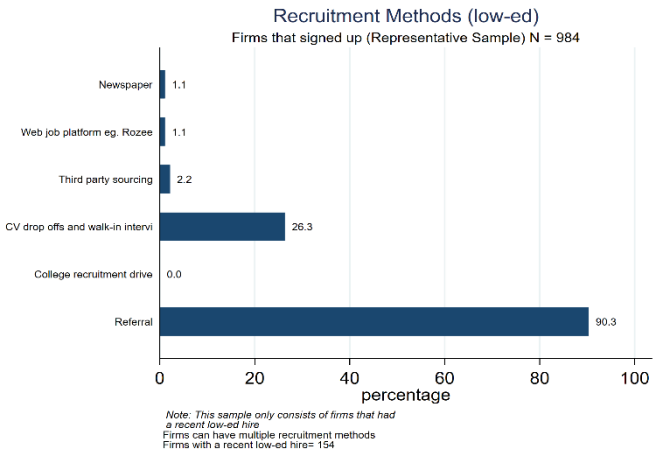
Out of the employers who signed up for the Job Talash service, over 29% listed jobs on the Job Talash platform immediately. The majority of the firms who signed up had not advertised jobs in the newspaper or a web platform for the vacancy, and used referrals or word of mouth as their primary means of recruitment (Figure 42).

Figure 42: Recruitment method used by firms to hire for a vacancy

(a) High school and above



(b) Below High School



Interestingly, out of the firms that listed ads with us, most of these ads required lower levels of experience and education than their recent vacancies. The level of education required in the jobs listed on Job Talash is lower than the education of firms' recent hires (Figure 43). Similarly, the required level of experience of the jobs on the Job Talash platform is lower than the experience of their recent hires (Figure 44).

Figure 43: Education of Recent Hire and Ad Listed

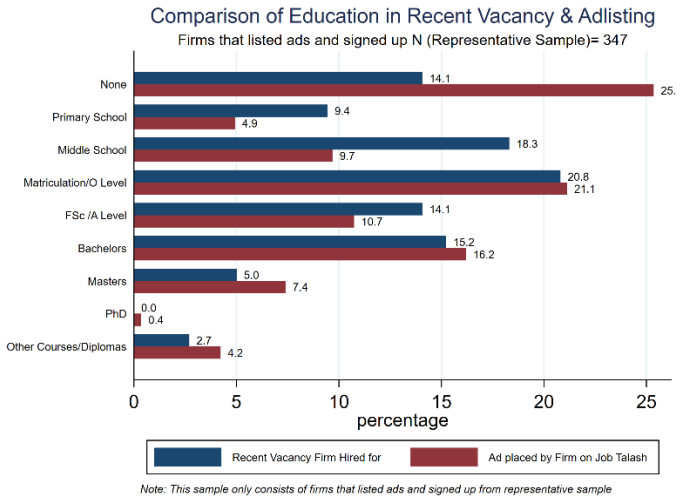
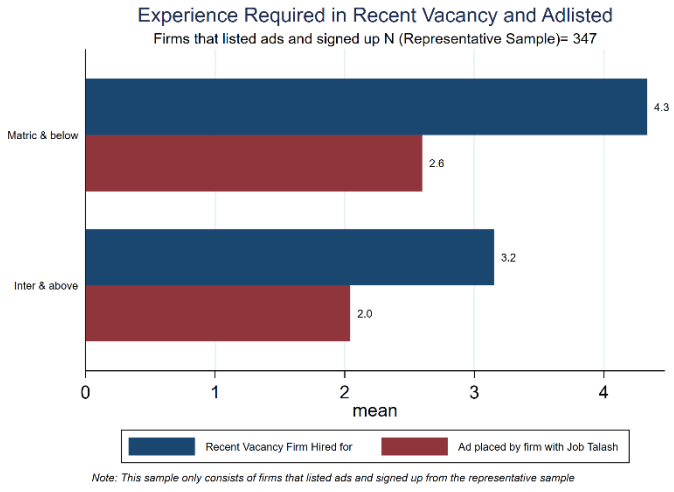


Figure 44: Experience of Recent Hire and Ad Listed

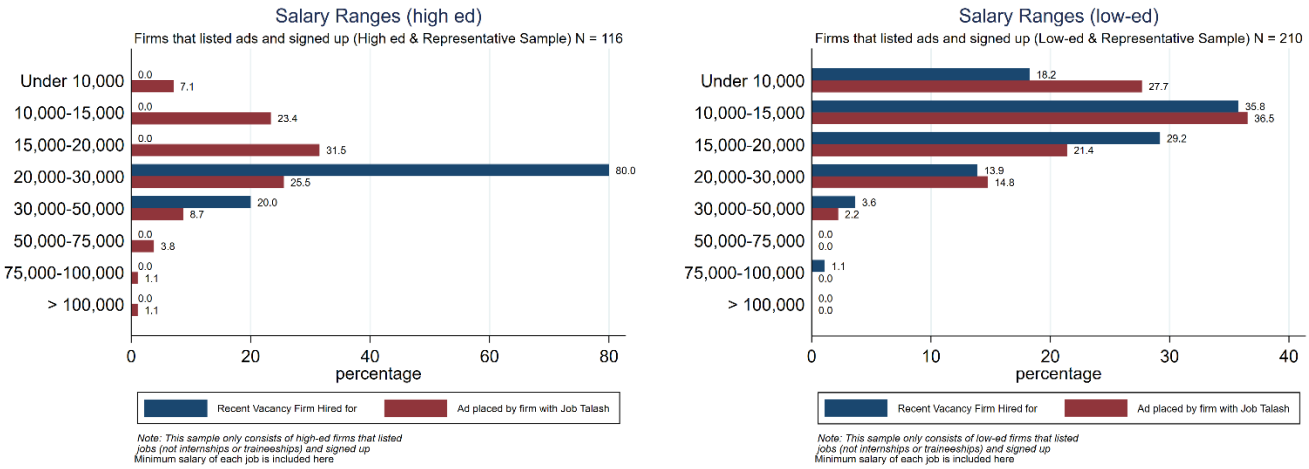


Around 26% of the jobs listed on Job Talash require no education while only 14% of the firms had recent hires with no education. These figures suggest that the Job Talash platform is mostly used by firms to advertise for low experience and education jobs. Most of these of these jobs are mostly filled by referrals (Figure 42 b), so it is interesting that firms are using the Job Talash platform instead to advertise these vacancies.

For most high education jobs listed on our platform, the minimum salary listed is not lower than what is paid to recent hires (Figure 45 a). The same holds for lower education jobs where the salaries listed with us are lower than what is paid to recent hires (Figure 45 b).

Figure 45: Salary Ranges of Recent Hires and Adlisted

(a) High Education *(b) Low Education*



While larger firms are more likely to have female employees, the majority of firms have no female employees, irrespective of size (Figure 46). Firms with no female employees do consider female applicants (either preferring female applicants or showing no gender preference) for around 30% of the job ads posted by them (Figure 47 a). Firms that already have at least one female employee are more likely to consider female applicants for vacancies. For at least 65% of job vacancies, such firms ask to see applications from female candidates (Figure 47 b). Of all the job ads posted on Job Talash, 43% were accepting applications from female candidates. These figures suggest there may be latent demand for female labor; combined with the data on latent supply discussed above, there seems to be potential for an increase in female labor force participation in this labor market.

Figure 46: Most firms have no women

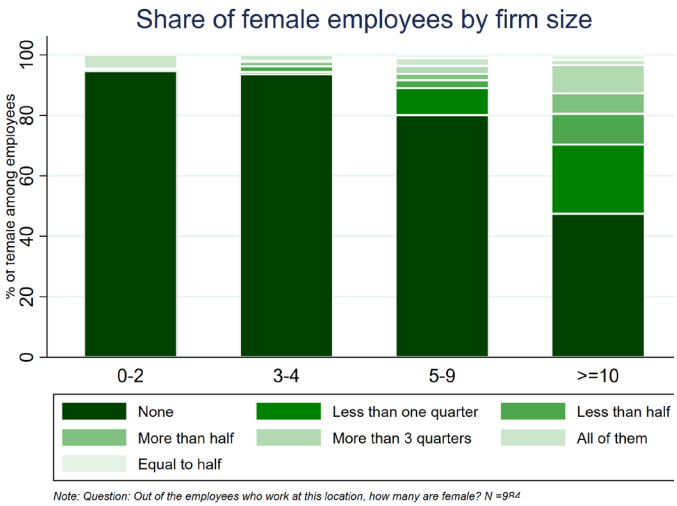
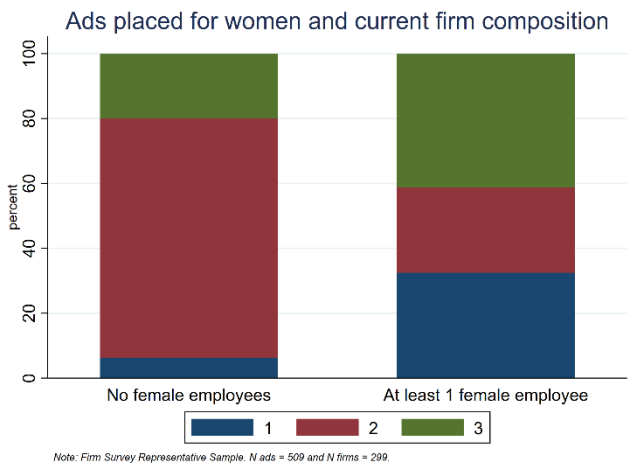
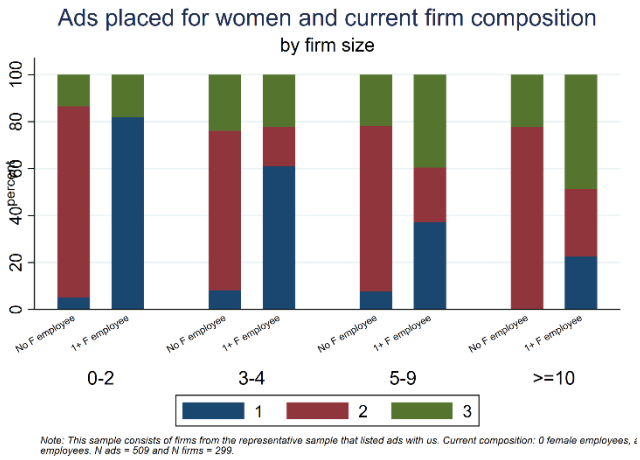


Figure 47: Firms without women are willing to hire them



(a)



(b)

2.3.2.1.2.2. Description of the qualitative sample

Three sets of open-ended interviews took place during the course of the study.

The first set of open ended interviews took place in March 2016 before the baseline survey of firms had started. Interviews were conducted with 8 firms, and recruitment for firms was network-based. This sample included firms from a variety of sectors including manufacturing, education, non-profit, banking and telecommunications.

A second set of qualitative interviews was conducted in December 2018 with 12 firms in a commercial area within the selected geographic sample for the survey. These included firms from service industries looking for low-skilled workers such as restaurants, car repair, furniture and electronic shops.

A third set of qualitative interviews was conducted in June 2019 to gather in depth feedback from 12 firms that were part of the geographic sample of firms selected for the study and were successfully provided Job Talash job matching and application services.

One focus group of employers was also conducted over the course of the study. HR representatives from 6 organizations in Lahore joined the focus group. The sample of firms selected for this purpose was network-based and included HR representatives from banks, schools, software, and transport industries.

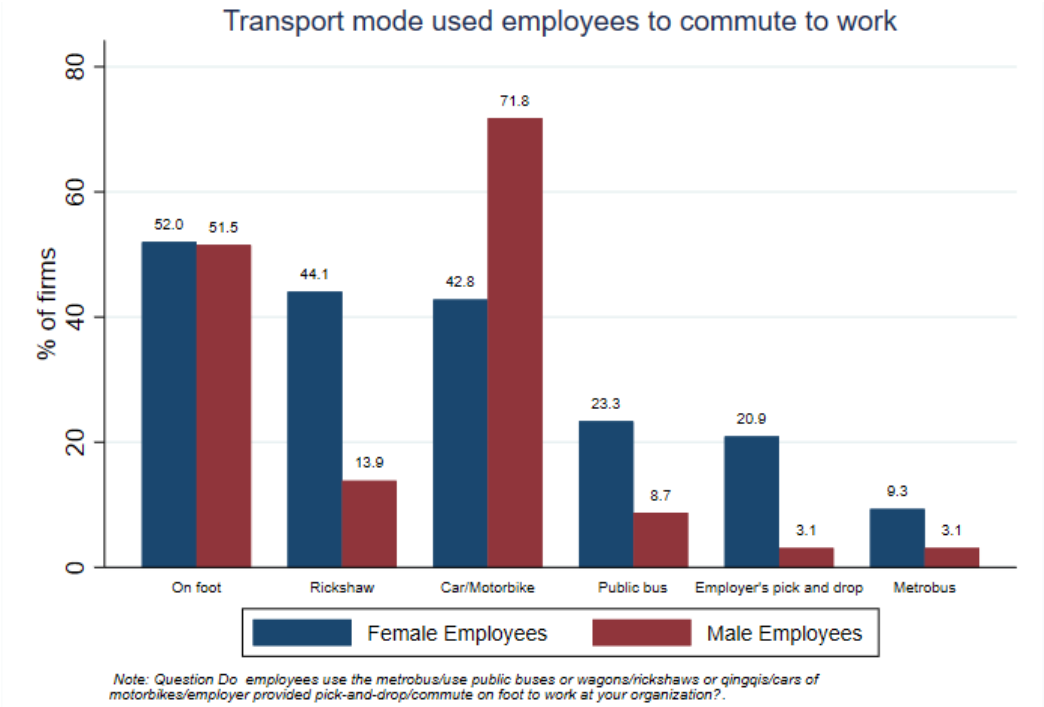
2.3.2.1.2.3. Comparison of survey sample with national population

Urban Lahore is more urban, higher-income, and more educated than the country as a whole. Within Lahore, the household and employer survey samples are representative except for the exclusion of military areas where permission was not granted for surveying (these are very high-income areas of the city which originated as areas where military officers receive land as a benefit for service).

2.3.2.1.2.4. Descriptive statistics on use of transport and hiring practices

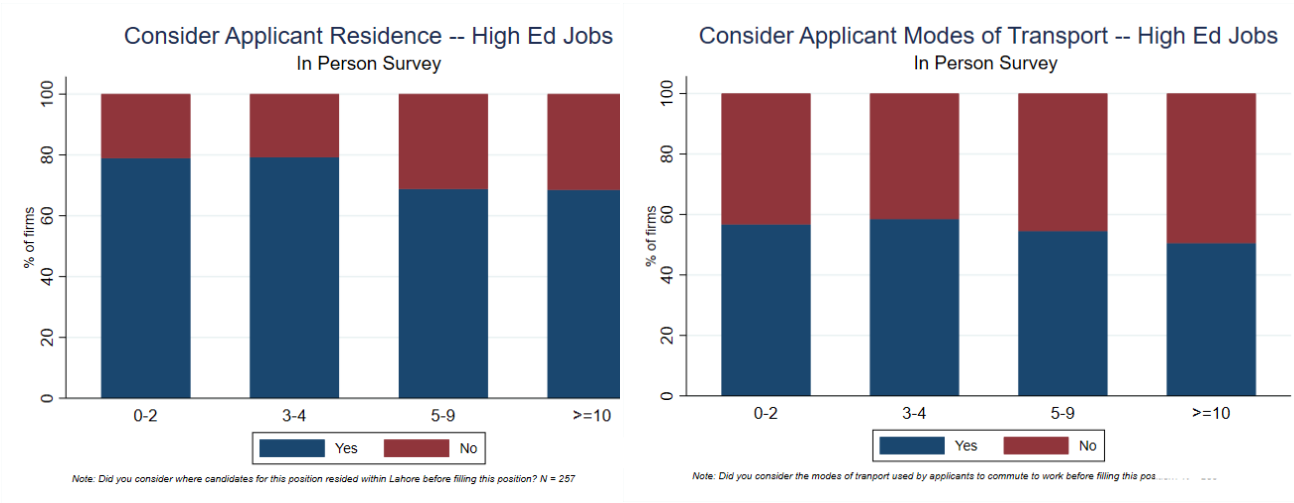
When asked how firms' employees commute to work, we see significant differences in responses for female and male employees. We asked firms whether females and males use a number of different transport modes. Figure 48 below shows the results to that question and indicate that women are more likely to walk or take public transportation compared to men, 71% of which commute using their own car or motorbike.

Figure 48: Firms response on their employees' transport mode for commute



Firms of various sizes, report that they consider where job applicants live in the city and the mode of transport they will use to commute to work when evaluating the applicants (Figure 49). Despite the indication that transport mode used to work is an important consideration in hiring decisions, only 4% of the employers surveyed provided any kind of transport to their employees (Figure 15). Only 14% of the employers surveyed showed willingness in contributing to the cost of a pick-and-drop service for their employers, and this statistic did not vary much across firms of different sizes (Figure 54**Error! Reference source not found.**).

Figure 49: Firms consider where job applicants live and how they commute when making hiring decisions, by firm size



(a) (b)

2.3.2.1.2.5. Findings from qualitative sample

During qualitative interviews, employers were asked about the challenges they faced while hiring men and women for their organizations. In terms of hiring for male candidates, firms said they either faced no difficulties or said they faced problems of attrition or union pressures. However, the same organizations when asked about the difficulties faced in hiring women mentioned issues such as “distance from home to work,” “pick drop issues”, “limitations on field travel” and “cultural obstacles.” Another challenge they faced in case of hiring women was retention at jobs after marriage and having children.

When asked about transport modes used by employees, all employers said male employees arrived to work on motorcycles or cars. However, for female employees, they said either brothers or fathers dropped them on car or bike, or they used rickshaw/qingchi if travelling alone, or company provided transport was used. One organization even went on to say that they used to have an HR policy earlier about immediate relatives not being allowed in the same organization, but they changed that to make husbands and brothers of tentative female employees eligible to stop losing good female staff. This was because women couldn’t travel alone to the organization (which was far located far from the city center) and had to be dropped off by husband/brother/father. If the men worked somewhere completely different, they would not be able to drop off the women and these women wouldn’t have been able to work.

Some of the firms provided a pick and drop service to their female staff. They said they needed to do this to ensure the safety and security of their employees, implying that they felt it was unsafe for females to be travelling on public transport. Interestingly, for the firms in this sample that exclusively had female employees, or a majority of female employees, business owners said provision of transport was fundamental to the sustainability of the business since they felt regular and punctual staff attendance would be impossible without it. For instance, a manager at a beauty parlor said, “We offer transport because it is very difficult for girls to come on their own. It is absolutely crucial that we offer it so that our staff can be punctual and can come regularly; our entire business would fall flat if we end it. Take my own example, I am a manager at this parlor, but I personally could not have ever worked here if they did not offer pick drop to me, distance from home is a big problem even for me, let alone my staff.”

The employers in the sample who did not offer transport said it was mostly because of the logistical difficulty of organizing it. These employers also recognized the importance of transport in employee work decisions, and compensated for the lack of an employee transport service by facilitating car loans and giving fuel allowances to employees.

One set of interviews was conducted with employers to understand the skills they need in employees and the means they use for verifying these skills, and how receptive they would be to skills testing services introduced by Job Talash. Their responses were used to design the skills list used in the survey instrument, and design further extension studies on information frictions in the labor market.

Another set of in depth interviews was with firms that had received Job Talash services. Their feedback on the service was used to modify certain aspects of service delivery and improve the experience firms had with the Job Talash platform.

From the focus group of employers, we received employer insights regarding framing and scripting for the survey instrument, as well as what questions are deemed sensitive, what incentives will work best for getting firms to participate, and who the best person to talk to would be at any organization for the research. The responses were incorporated in the design and implementation strategy of the baseline survey for firms.

2.3.2.1.3. *Merits of using Job Talash to collect labor market data*

There are some differences between the of employers and jobseekers who signup to Job Talash and those who do not, specifically related to the overall hiring practices of employers. However, these differences are not as great as one may assume from more popular web-based job search platforms, which are likely used more for hiring comparatively highly educated candidates on jobs posted by larger, more formal employers. One important merit of call center-based platform like Job Talash is its accessibility to jobseekers and employers that have or require a wide range of education and work experience levels which enables Job Talash to capture a larger slice of the labor market. As a result, we can see who responds to the intervention across these segments of employers and jobseekers.

Another major advantage of the Job Talash platform is the rich data it generates on the interactions of jobseekers and employers. Using the data on job ad matching and job applications, we are able to track who is matched and who applies to which job ad as well as further outcomes for every single match. The following figures are examples of the kinds of information about the labor market that the Job Talash platform can generate. We see that the majority of job vacancy-jobseeker matches in the Job Talash platform had a distance of 20 km between the neighborhoods of the employer and the jobseeker.

We see that even though a lower proportion of female jobseekers are matched to jobs compared to male jobseekers, the percentage of job applications to job matches is slightly higher for female jobseekers compared to male job seekers. Similar statistics can be generated for jobseekers and matches by household income rather than gender.

2.3.2.2. Research analyses and *Heterogeneity of impacts*

Component 2's RCT is still ongoing. Preliminary results to date show that women respond to offers of transport rather than men. We find that female jobseekers' probability of applying to a position increases sizably when the job is accessible by the commuting service, while male jobseekers' decisions are unaffected. This response is driven by the women-only transport offer, for which the estimated effect is much higher than that for the mixed transport offer. This suggests that not only cost and convenience, but also avoiding harassment and stigma play an important role in mobility constraints on female labor supply. A cash transport subsidy of equivalent value is currently being rolled out as a further test of this mechanism. Preliminary results also show that offering transport brings in "latent jobseekers" who were not searching at baseline. This suggests that reducing constraints on women's mobility could ultimately bring more women into the labor force.

The researchers plan to release a working paper in early 2020 based on the results to date in which the results and the heterogeneity of impacts will be discussed in more detail.

2.4. Cost analysis

The intervention consisted of providing pick-and-drop transport services to subscribers between their homes and workplaces. Since the job placement rate of the jobseekers through the Job Talash platform has been very low, we are conducting new experiments to understand the reasons for and possible solutions to address the low placement rate.

The low job placement rate also restricted the transport intervention's take up among jobseekers, even though we find evidence of people's interest in the transport intervention offer that is communicated to them at the time of sending them job alerts. Therefore, instead of sharing the cost analysis on an ongoing intervention, we are sharing the cost analysis of the transport intervention pilots we conducted to prepare for the intervention scale up.

We followed the J-PAL Costing Guidelines and Template for the cost analysis using the recommended "Ingredients Method" of costing. The following is a summary of the costs incurred for the intervention pilot. Details of the calculations are attached in Appendix C.

We made the following general assumptions related to the cost calculations:

- The intervention pilot started in December 2015 and ended in June 2016. Therefore, the costs are from the same period, i.e. 2016. The calculations do not consider increase in costs (due to inflation, currency depreciation, wage increases, or other factors) since 2016.
- The unit for beneficiaries is User-Months. The program enrolled a total of 28 users in the program over a period of 7 months. One user-month refers to one user being enrolled in the program for one month.
- USD/PKR Exchange Rate used was 104.50, which was the average exchange rate between December 2015 and June 2016.

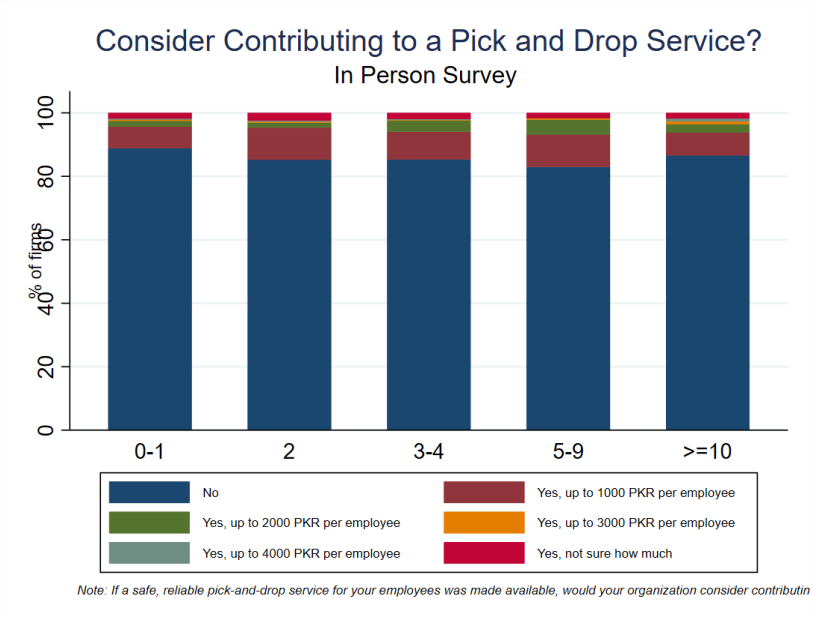
Table 14: Cost Analysis for Transport Intervention Pilot

Costs	**Amount in USD**	**Notes**
Program administration and staff costs. *Cost of all full-time staff who worked throughout any phase of the intervention and implementation and other costs related to program administration. Does not include the cost of evaluating the program.*	4,701	Salaries of 4 team members staff, two research staff and two support staff, working on all aspects of the program, including training, monitoring, targeting/marketing, admin, and implementation. Details of allocation of each team member's time to each component are included in Appendix C.
Targeting costs *Costs that were incurred to target, identify, and raise awareness among potential subjects as part of the intervention.*	12	Targeting costs were small since the service was rolled out for a limited number of employers/firms situated within a small geographic area.
Staff Training *Costs that were incurred to train staff involved in the intervention*	-	Training costs only comprised of staff time, which has been covered in program admin costs.
Participant/Beneficiary Training	-	There was no training targeted at participants.
Implementation and program material costs	26,630	Almost all of this cost was the cost of transportation, which was the service being provided by the program. The transportation cost is based on operating a pick-and-drop service with 6 vehicles on average for 7 months, each with a route 25 km long (oneway) between the users homes and offices. Details of the calculations are given in Appendix C.

User Costs *Costs that the user incurred as a part of the intervention*	6,141	Users were charged a monthly fare for the pick-and-drop transport service. The fare had a fixed component and a variable component which was based on the driving distance between the user's home and office.
Averted Costs *Any costs averted as a result of the intervention*	5,489	These are estimated costs that the user would have incurred for the commute between her home and office for the duration of the program. Note that Averted Costs have been subtracted from the Total Program Costs, since enrolling in the program allowed the users to avoid those costs.
Monitoring Costs *Costs incurred to oversee and monitor activities during the intervention*	906	Much of the monitoring was done through tracking the vehicle's routes and timings by mobile applications to ensure a high quality of service delivery.
Total Program Cost	**32,900**	Averted Costs have been subtracted from the total program costs, since enrolling in the program allowed the users to avoid those costs.
Average cost per user-month	**279**	Reflects the cost per beneficiary at a 51% utilization rate (or occupancy rate of vehicles).
Marginal cost to add a user-month *Estimated cost to extend the program to an additional user-month.*	**135**	This is the average marginal cost incurred by the program when considering the last 5 users enrolled for the intervention (i.e. 4.5 user-months, as one person joined for 0.5 month). We assume that new users are accommodated in the existing vehicles, since the program's occupancy rate (for vehicles) peaked at an average of around 51%. Potentially, the program can accommodate almost as many users as were enrolled in the past. This is conditional on the pick-up and drop-off locations being on or near the existing routes.

The marginal cost to add one user-month must be considered in the context of the finding that 14% of the employers surveyed showed willingness in contributing to the cost of a pick-and-drop service for their employers (Figure 50**Error! Reference source not found.**). The contribution amount per employee is much lower than the marginal cost to add one user-month.

Figure 50: Firms willing to contribute to transport service for their employees



2.5. Discussion

2.5.1. Introduction, challenges and lessons

Our forthcoming working paper (Field and Vyborny 2020) discusses the findings in more detail. Preliminary results of the research are discussed in section 2.3.2.2. In this section, we discuss the conclusions and implications of the results.

The RCT results to date show that offering transport to work makes a large, significant impact on job applications for women, but not for men: mobility around the city is an important constraint to female labor supply. Offering transport leads those women to apply for jobs who were not applying for jobs on or off platform previously – suggesting the potential for improved mobility to eventually increase female labor supply on the extensive margin, i.e. bring more women into the labor force. The difference between the women-only and the mixed-gender transport offer shows that not only cost and convenience, but also avoiding harassment and the stigma of traveling with men, are important factors for women.

For employment outcomes to ultimately improve, applicants must move past the application stage. Firm followup data indicates that applicants are invited to interviews at a rate of about 5.5%. Female applicants are invited to interviews at higher rates than men, suggesting that bias against female jobseekers may not be the binding constraint for Job Talash jobseekers to be hired through the platform. The effect of the transport offer on interview invitations is imprecisely estimated; but the pattern of results is qualitatively similar to the effect of the transport offer on applications overall.

For the option of increased mobility to translate into economic benefits for workers and firms, and for the full scope of the urban labor market to be realized, candidates and firms would need to search for and accept matches outside their existing networks, which are more limited in scope and may be limited in geography. The Job Talash research program is using our results so far to identify challenges to reaching this outcome, and has begun piloting and testing complementary interventions to address each one:

1) At baseline, the majority of candidates search through their networks – far more than through any other means of search. Qualitatively, we have found that many candidates are unfamiliar with the

concept of a job "posting" open to many people, and Job Talash counselors had to explain this in detail to jobseekers for them to understand that they might need to apply to many postings before getting a job offer. For the full scope of the urban labor market to be realized, candidates may need to learn how to use more formal, wider job search mechanisms, outside their social networks. To test this, we have implemented a randomized encouragement treatment. All Job Talash subscribers receive job postings that match their qualifications, but half also receive a followup call after each batch of postings to encourage them to apply. This treatment makes a large impact on rates of applications; this effect persists to a significant increase in interview invitations and interview attendance.

2) Some firms indicate that they screen CVs to avoid candidates who live far away. This would dampen the effect of the transport offer on interview invitations and ultimately employment. To test this formally and overcome it, we are testing an intervention in which we either (a) remove the residential location from the candidate's CV; (b) inform firms about the transport offer received by the candidate, or both. This allows us to test formally whether firms screen on distance, and whether the transport intervention reduces that effect.
3) Although many firms post ads with Job Talash, the majority of firms still appear to conclude their search by hiring candidates they know through their networks. As with jobseekers, firms may be risk averse: when it comes to signing up and posting an ad for free, they are ready to participate, but when it comes to hiring candidates they do not know through their network, they may not want to take the risk. We have planned two interventions to address this. First, we have piloted a process of reference checks, one of the most demanded screening services by firms. We have piloted a randomized reference check announced to jobseekers before they report updates to their CVs. We find that this does not discourage people from reporting up-to-date work experience, but in pilot findings there is suggestive evidence of a decrease in exaggeration on the achievements reported on the CV. We are now scaling up this intervention and will incorporate it on the jobseeker side with existing jobseekers as well as participants who will sign up in workshops in Autumn-Winter 2019. In early 2020, all jobseekers will have their references checked, and randomly selected employers will start to receive application packets including reference reports for all jobseekers. This will allow us to test whether reducing this information friction increases hiring through Job Talash instead of through social networks.
4) A second intervention which may help to mitigate firms' concerns about hiring outside their network is a short-term subsidy to help firms cover part of the cost of wages during a one month "trial period," potentially offsetting costly investments of time in training and assessing a new employee on the job. This may be particularly valuable for jobseekers with limited formal experience, including a large number of recent graduates in the sample. Preliminary qualitative work with firms suggests a high level of interest in testing out this scheme.
5) In follow-ups, firms frequently report that candidates are invited to interviews but do not attend them. There are many reasons this could take place. One is again physical mobility: in particular, women who are responding to the transport offer for commute by applying to a job may have difficulty in reaching the firm for an interview. We have piloted transport to an initial interview, and are now scaling this up.
6) In addition to physical mobility, communication with candidates is a challenge. In followups with firms, some firms report that they called a jobseeker who didn't show up to an interview, while the jobseeker reported not hearing from the firm. Approximately 50% of the women in our sample share a phone number with a family member, and it frequently takes multiple attempts for our call center to reach a candidate, particularly during working hours when male family members who control phone usage are at work and cannot hand over the phone at home. In such cases, respondents often request a call back in the evening or on the weekend. There may be a communication gap in which firms communicate the offer of an interview to a family member who does not pass on the message. To

help reduce this friction, we are piloting interview intermediation in which we communicate between the firm and the jobseeker during the interview process. In addition to addressing this friction, this will also help to improve the quantity and quality of follow-up data we expect to receive from firms after interviews.

2.5.1.1. Policy Implications

The findings from this research will be useful to policymakers in several ways. First, it will establish a quantitative evidence base on the importance of urban transport for employment. This will help to inform the national urban transport plan, which has been a top priority for the national and Punjab governments; several policymakers have reached out to actively follow up on discussions of this and a related urban transport project to request information on the research findings. Second, it will test out and directly inform decision-makers on the specific costs and benefits of a transport-to-work intervention. After the study, this could be operated privately or through a public-private partnership. We anticipate that the intervention could become financially self-sustaining for some areas. However, in the medium run the intervention might require public support in more remote or marginalized areas, which may be a priority for public agencies in order to promote economic and social integration.

Additionally, understanding how firms are affected by being able to more easily hire women will substantially enhance the public policy implications of improved transport for women. For instance, it will allow the researchers to analyze whether any change measured on the labor supply side represents a shift between treated and untreated women in the same jobs, or if firms are actually able to hire and retain more women as a result of the treatment.

2.5.1.2. Other challenges and their solutions

In addition to the logistical challenges of operating Job Talash service, we also encountered some challenges during piloting when competitor rickshaws spread negative rumors about the transport service. To combat this, we are established credibility with participants through running the job matching service at baseline for several rounds before offering the transport.

Our government partner for this project has been the Punjab Commission on the Status of Women. However, with the change in the government last year, the leadership and staff of the Commission that we had been in close liaison with, has been replaced. One big challenge is to keep our collaboration with the Commission ongoing despite the change in government. As of now, no new leadership of the Commission has been assigned.

We have tackled this challenge through reaching out multiple government agencies that may potentially partner with us for this study. As a result, we have signed a MOU with the provincial Social Welfare Department and are in further discussions with the department about detailed next steps for how they can support our activities. Additionally, we had reached out to leadership of the Commission's parent agency, the Women's Development Department. However, the leadership of the parent was recently changed and we are now in the process of reaching out to the new lead of the parent agency.

2.5.2. Policy and programme relevance: evidence uptake and use

Please refer to section 2.5.1. for this discussion.

2.5.3. Challenges and lessons

Please refer to section 2.5.1. for this discussion.

2.6. Conclusions and recommendations

Please refer to section 2.5.1. for this discussion.

Appendixes

The following appendixes have been submitted with this report and are placed in a separate folder during submission:

- Appendix A: Working paper that contains Component 1's study and findings
    - Majid, Hadia. Malik, Ammar. Vyborny, Kate 2018. Infrastructure investments, public transport use and sustainability: Evidence from Lahore, Pakistan.
- Appendix B: Working paper that discusses the development of a structural model of joint work and residential location choice accounting for differential access to transportation options and preference heterogeneity
    - Yin, Chuhang 2018. How Does Preference Heterogeneity Drive Work and Residence Location Choice? Evidence from Lahore, Pakistan.
- Appendix C: Details of cost analysis based on JPAL's costing template for Component 2

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