Impact and Incidence of Housing Subsidies in Urban Slums: Evidence from India

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Abstract

Improving housing conditions in urban slums is a key challenge in developing countries. Public programs to transition slum dwellers into formal houses require them to demolish their existing dwelling and make complementary investments — raising concerns that the poorest households will be excluded. This paper studies India's flagship house construction grant, PMAY, and finds that despite these participation costs the program is progressive: the share of households receiving the grant decreases from 19% in the poorest income quintile to 12% in the richest. The key mechanism is that the value of the existing dwelling is an income-correlated participation cost — richer households have more to give up and are less likely to take up. The causal effect among recipients of the program on house quality is 0.61 σ , driven by a 60pp increase in the probability of having a concrete roof, with no detectable effects on unverified dimensions such as toilets or windows. A welfare framework shows that the program take-up rate is a sufficient statistic for welfare benefits, and that holding the budget fixed, giving a larger grant to fewer households would increase aggregate welfare transferred.

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I am grateful for guidance and support to Karthik Muralidharan, Paul Niehaus, Craig McIntosh, and Fabian Eckert. I have greatly benefited from helpful discussions with Achyuta Adhvaryu, Sam Bazzi, Prashant Bharadwaj, Gordon Dahl, Gaurav Khanna, Anup Malani, Tom Vogl, and various seminar participants at UC San Diego, ISB Hyderabad, and PacDev. The study was pre-registered with the pre-analysis plan available at https://osf.io/c6zmw/. IRB approvals were obtained from UCSD IRB and ISB IRB. I am grateful to Mr Mathi Vathanan, Mr Sangramjit Nayak, and Mr Sushant Mishra of Government of Odisha for their guidance and willingness to collaborate on this project. I thank Dr Antarin Chakraborty of Centre for Policy Research, and Mr Srinivas Alavilli, Ms Ankita , Ms Suchismita Sahoo, and Ms Nikita Mishra of Janaagraha Foundation for very useful discussions about the intervention and providing access to the program data. I am thankful to Sambhav Choudhury, Shreyansh Dwivedy, Winfrey Kong, and Jiawei Yang for providing excellent research assistance. This project was financially supported by Co-Impact New Venture Fund, Weiss Fund for Research in Development Economics at the University of Chicago, CEGA Development Research Challenge Grant, and UCSD International Institute Travel Grant. All errors are entirely mine.

1 Introduction

Over a billion people across the world live in slums with poor quality shelters and unhygienic conditions.[1] Governments in low-income countries have designed housing programs to move them into better houses in the same neighborhood or elsewhere. However, households often need to supplement government subsidies with private investments, or overcome ordeals like application costs and arranging alternative accommodation during construction, or suffer disruption of economic networks. This raises the concern that the poorest households get excluded from such programs. Further, because typically such programs raise the quality of house to a fixed level, the net improvement in house quality would mechanically be lower for people with a better house to start with. The incidence and impact of housing programs is therefore ambiguous and depends on the program's design.

In this paper I study Pradhan Mantri Awas Yojana (PMAY), the flagship housing scheme of the Government of India costing 1-2%[2] of the national budget and targeted at 20 million poor urban households. In this *in situ* housing program beneficiaries receive Rs 200,000 (USD 2,500)[3] in installments contingent on verified construction milestones to construct a house with a concrete roof on the same land that they currently occupy. The beneficiaries need to demolish their existing structure to lay a new foundation that can support a formal house. Households need to have tenure documents for the land to receive the benefits.

To identify the causal impact of the program I exploit variation from a parallel program, the Government of Odisha's JAGA Mission. The government gave tenure documents[4] to those occupying state or municipal lands (henceforth *tenable* households) but lacked jurisdiction to do so for those occupying private, temple, railway, forest, or central government lands (henceforth *untenable* households). Since slum dwellers settle on vacant lands with no knowledge of its formal owner, this generates exogenous variation within the slum in the eligibility for housing grant.

The government conducted a census of all slum dwellers that serves as a baseline measure of household income and house quality. I use administrative land records data to identify the formal owners of the land. I conducted an endline survey among 5,917 slum households across 11 towns, five years after the roll out of this intervention, to measure the incidence and outcomes.

[1] United Nations Sustainable Development Goals Report, 2023

[2] In the years 2016-2024 the government has allocated Rs 3.89 trillion or about 49 billion USD for the combined implementation in rural and urban areas across India.

[3] This is about 2 times the median annual household income

[4] The tenure document cannot be sold or transferred to a different person unlike a land title.

Despite the ordeals of demolishing their house, arranging alternative accommodation, and making complementary investments upfront, the incidence of the program is progressive even among slum dwellers[5]. The share of households who have received the benefits decreases from 19% in the poorest quintile to 12% in the richest quintile. The progressivity is driven in part by the richer households opting out: conditional on being invited to apply, self-reported application rates decrease by 5pp from the poorest to the richest quintiles, self-reported willingness to take up the program decreases by 5pp, and the threshold level of benefits at which they would take up increases by 15% from the poorest to the richest quintiles.

The key mechanism is the opportunity cost of taking up the program: the value of the house they must demolish is higher for richer households who have typically invested more in their current dwelling. Since house quality is positively correlated with their income, this generates progressive take-up. We see that the measures of progressivity decrease by 21% when we control for baseline house quality.

Tenable households have a house quality index[6] 0.05σ (p-value: 0.09) higher than untenable households in the same slum. This corresponds to a LATE of 0.5σ of receiving the grant, rising to 0.99σ after reweighting households to account for the construction phase. This is equivalent to the housing gap between households with Rs 20,000 (1.1σ) difference in annual income. The impact on the index is driven by a 60pp impact on having a concrete roof and a 22pp impact on having a brick wall. Both these measures are verified by government officials before the grant money is released. On other measures like having an exclusive toilet, more windows, or safer electrical connections which are not verified we can rule out even small effects.

The impact of the program is concentrated among the households in poorest quintile where the incidence is the highest. Further, the poorest beneficiary households have a large net improvement in house quality since they start from a poorer quality house. Consequently, the LATE estimates decrease from 0.84σ in the poorest quintile to 0.34σ in the richest quintile.

I provide a theoretical framework to study the welfare impacts of the program and estimate optimal benefit levels. In the model, households choose to take up the grant if the utility gain from a better house exceeds the opportunity cost of demolishing their existing dwelling. Under assumptions about the distribution of idiosyncratic preference shocks, I show that the program take-up rate is a sufficient statistic for the average welfare benefit of the grant — a result that

[5]The program would be even more progressive if we considered the entire city population

[6]The index is the first principal component of a set of measures about the roof, wall, floor, number of rooms, windows, toilet, and other safety features of the house.

holds independently of the functional form of household utility. Using this result and calibrating the model to the survey data, I find that the current benefit level of Rs 200,000 is at a local minimum of the welfare curve: many poor households cannot afford the complementary investment needed to participate at this level. Holding the total budget fixed, increasing the grant amount and reducing the number of beneficiaries would enable poorer households who are currently priced out to participate, raising aggregate social welfare.

This paper contributes to multiple literatures. First, this paper contributes to the literature on the role of ordeals in the incidence of public programs. Ordeals like application costs can deter the households who value the benefits the least from applying for it(Nichols and Zeckhauser, 1982; Alatas et al., 2016). However, ordeals may make program incidence regressive if overcoming them is more costly for the poor. This may be due to application costs being difficult to meet (Romero and Singh, 2023; Gupta, 2017; Finkelstein and Notowidigdo, 2019; Deshpande and Li, 2019) or behavioral frictions like inattention (Shepard and Wagner, 2022; Bertrand et al., 2004). Similarly the need to complement the transfers can make the incidence of housing programs regressive (Rondinelli, 1990; Michaels et al., 2021). This paper identifies a different mechanism: when participation requires forfeiting an existing asset, the asset's value becomes a participation cost that is positively correlated with income and generates progressive incidence. This mechanism generalizes across programs where participants must forgo an asset: workfare programs where the asset is an outside job(Besley and Coate, 1992; Ravallion, 1991), and public school programs where the asset is the quality of the outside school(Romero and Singh, 2023).

Second, this paper contributes to the literature studying housing for the urban poor. Programs like providing titles (Field, 2005, 2007; Galiani and Schargrodsky, 2010), construction materials (Cattaneo et al., 2009; Galiani et al., 2017), or improved public services (Michaels et al., 2021; McIntosh et al., 2018) lead to modest improvements in house quality. Despite such measures the urban poor persistently live in slums over many years. Marx et al. (2013) suggest that slum dwellers might need a "big push" to grow out of poverty and live in improved houses. Interventions that move households elsewhere disrupt their economic networks and see a low take up (Picarelli, 2019; Franklin, 2020; Barnhardt et al., 2017). In contrast, we find that beneficiaries of this *in situ* program experience large improvements in house quality — consistent with the big push hypothesis and without the disruption costs of relocation.

Finally, this is the first well-identified study of PMAY, India's largest housing program, accounting for 1-2% of the national budget and targeting 20 million poor urban households. Despite its

scale, credible causal evidence on its incidence and impact has been absent. Well-intentioned and well-funded public programs can fail to reach the poorest due to corruption and leakage (Muralidharan et al., 2016), poor implementation (Pritchett, 2009), or mis-targeting (Romero and Singh, 2023). I find that PMAY does not suffer from these failures: the program reaches the poorest households at higher rates, delivers large improvements in house quality, and generates the greatest gains for those who need it most.

2 Context and Intervention

2.1 Context

This project is based in Odisha, India. Odisha is one of the poorer states of India with a per capita GSDP of 1,600 USD. The state had a population of 42 million in 2011 of which 16.7% lived in urban areas. There are 114 urban local bodies in the state and in this project we will focus on the 109 municipalities and notified areas in the state which accounted for about 61% of the urban population in 2011.[7]

Slums are a common feature of most cities and towns in India. As of 2011, 17% of all urban households lived in slums across the country. In Odisha, 23% urban households lived in slums. (Census of India, 2011) The Government of Odisha defines a slum as a compact settlement of at least twenty households with a collection of poorly built tenements, mostly of temporary nature, crowded together usually with inadequate sanitary and drinking water facilities in unhygienic conditions. The state government has identified nearly 1500 slums across these cities and towns. About 160,000 households or about 500,000 people live in these slums.

Slums develop organically as people migrate from rural to urban areas. Increasing structural transformation has lead to people move to towns and cities in search of better employment opportunities. Such people set up a temporary shelter at vacant lands in the city. They usually start with a house made of tarpaulin sheets and progressively build a more formal structure using bamboo sticks, mud, metal and asbestos sheets, and bricks (Rains and Krishna, 2020).

The slum households do not usually have any formal land documents. They are squatters on the land. However, over time they build different forms of de facto and de jure land rights. The de facto land rights come from their neighbours and other slum dwellers recognizing their claim to

[7]The study does not include the 5 municipal corporations where the program implementation had not begun until 2022

the land. This even allows the households to sell their land in informal land markets and transfer such de facto rights. Households may also hold different documents that tie them to their land. Households usually start with public utilities connections like electricity and water. They may also get some informal documents from the local governments. It is very difficult for slum dwellers to get full land rights for their land though. (Krishna et al., 2020)

Slum dwellers face two threats owing to their informal house. First, they face a threat of eviction by the government and other agencies. Slum dwellers are evicted from their lands whenever new developments are planned in those lands. They are usually left homeless by such actions and need to restart at a new location. Second, slum dwellers live in very poor and unhygienic conditions. In the context I study, about 8% households have a concrete roof while the rest have asbestos or polythene roofs. 52% have walls made of bricks while the rest have walls made of mud or bamboo. 30% households have a toilet in their house and 60% have access to any toilet. The poor living conditions are health hazard to the slum dwellers. They share toilets with a lot of people. They are susceptible to water-borne and communicable diseases. Their roofs are not resistant to heavy rain and their houses flood during rains. They also face a threat of pests during the rains. Children may also not be able to pursue education if they do not have a conducive environment and resources to study at home. Marx et al. (2013) suggest that these limits on human capital accumulation together with inertia in physical capital investments may create a poverty trap for these households.

Policy response to slums have usually taken the form of different housing programs, improvements in public infrastructure, and land titling programs. In the next subsection I discuss the intervention in this study.

2.2 Intervention: Prime Minister's Housing Scheme

Pradhan Mantri Awas Yojana (translates to Prime Minister's Housing Scheme, abbreviated as PMAY in this paper) is an Indian central government program to provide formal houses to the poor. The Indian government has instituted multiple housing programs like the Indira Awas Yojana in 1985 which was subsequently renamed as Rajiv Awas Yojana. The current program was launched in 2015 and builds on the older programs with an expanded scope and more generous benefits. The program was launched with the aim of ensuring all urban households have a formal house. The government proposed to provide houses to 20 million families over a period of 7 years and so far 11 million houses have been sanctioned. The program is partly funded by the state governments and implemented by the state governments through the municipal administrations. This program

accounts for 1.75% of the union government's budget for the year 2022-23.

PMAY program includes multiple strategies to provide housing including subsidized housing credit, government-led construction of housing shelters, and beneficiary-led construction. In this paper we focus on the third component which also accounts for over 70% of the houses sanctioned under the program. Under the beneficiary-led construction scheme, beneficiaries are given Rs 2,00,000 (USD 2,500) to construct a house on their own land. They need to break down any existing dwelling structure to lay a foundation. They must then raise a plinth and build a concrete roof. The households receive the money in 4 installments-after completion of the foundation, walls, roof, and the entire house.

To be eligible to receive the benefits, the households must meet four criteria: (i) They need to belong to the Economically Weaker Sections category or have a total household annual income of less than Rs 300,000. Nearly all slum dwellers meet this requirement.[8] (ii) The households should have a land title or formal tenure security for the land where they propose to construct the house. (iii) The family should not own a house or land elsewhere in the country.

The households desirous of benefiting from the scheme need to submit a set of documents to their local municipal authorities. The authorities then submit the request on a central portal. Some households receive a work order which confirms that they will receive money under the program. The household can then start construction. At the completion of each stage of construction the municipal authorities verify the status of construction. They click pictures of the construction site and upload on a portal. The households then receive money directly in their bank accounts.

The government grant covers a part of the cost incurred by the households. The grant amount of Rs 200,000 may be sufficient to construct a basic house in a small town. In a bigger city even a house with no additional amenities costs more than Rs 300,000. The households also incur costs in temporary stay arrangements during the construction phase. While some households stay with their families or neighbours, others find a house for rent temporarily or construct a small temporary shelter near their land. The households also need to make expenses up front and receive the grant money later on.

These costs can be thought of as complementary investments that a household needs to make to participate in the program. All housing programs have a component of such complementary investments or participation costs. The value of the current dwelling structure of the household is an additional opportunity cost faced by them because they need to break this down to participate

[8] According to the data collected by the government, all households report an annual income of Rs 250,000 or less.

in the program.

2.3 Odisha Government's JAGA Mission

To avail the house construction grant from PMAY households need to have a land title or tenure documents for their land. Most slum dwellers are squatters and have no formal land titles. Many of them have lived in the same land for a very long time and gain de facto land rights. They even manage to get electricity and water connections. But they do not have any documents that guarantee their security on that land. The Government of Odisha introduced a program to give land rights to these slum dwellers. There is variation in which slum dwellers have received these land rights and in turn variation in their eligibility for the housing grant. I use this variation to evaluate the causal impact of the housing grant. In this section I describe the program and in the next section how this yields identification for the causal impact.

The Government of Odisha launched JAGA Mission in 2017 with the aim of transforming all slums in the state into livable habitats with all civic infrastructure at par with the rest of the city. The government embarked on a four-pronged approach to achieve this. In the first phase, the government planned to provide tenure security to the slum dwellers through land rights certificates. In the second phase the government intended to provide basic civic amenities like electricity, water, sewage, roads, and public shelters in all slums. In the third phase, the slum dwellers were to be encouraged to build a formal house on their lands taking advantage of the house construction grants from PMAY. In the fourth phase, the slums were to be made an active part of planning development activities in their neighborhood through slum dweller associations.

The government passed a legislation in 2017 authorizing them to provide land rights certificates to all slum dwellers. A household with a land rights certificate (LRC) cannot be evicted from that land. This gives the households formal tenure security. However, unlike land titles, the land rights certificates are non-transferable. The households cannot sell, sublease or gift the land to anyone else. They can only bequeath the land to their heir. To implement the program, the government first imaged all slums using drones. They mapped each parcel of land with a family through a household survey. The land parcels data was also linked with the revenue department data to identify the official owners of the land. All households living on land owned by the municipal government or abandoned land immediately received the land rights certificates. The certificates were issued in the name of the woman of the house whenever possible.

The formal land owners are varied. Some of these lands were vacant. Some were owned by

the local municipal government or state government departments like municipal administration or public works department. In these cases the government could immediately give the slum dwellers the land rights certificate. I will henceforth refer to these lands as *tenable* lands in this paper. The other lands were owned by private individuals, temple trusts, erstwhile royal families, and central government departments like railways and forests. In these cases, the government can try to get the lands transferred from the other departments to the municipal government and then give the households the land rights certificates. In the case of privately owned lands the government cannot give the households land rights certificates for the same land and plans to move the households to a different government owned land. I will henceforth refer to these lands as *untenable* lands in this paper. As of January 2023 the government was still in the process of identifying and acquiring new lands to move these households. Less than 5 slums had been shifted to new lands at that time.

3 Empirical Strategy

3.1 Identification strategy

To estimate the causal impact of receiving the house construction grant I use the variation in the implementation of the tenure security program. I compare the households living on *tenable* lands with the households living on *untenable* lands within the same slum. As described in Section 2, the households living in tenable lands received tenure security immediately from the municipal government. Fewer households living in untenable lands had received the tenure security as of Jan 2023, the time period of this study. Only households who have received tenure security documents were eligible for the house construction grants.

For this identification strategy to be valid, we need the two types of households to be comparable and tenability exogenous to the outcomes. Slum dwellers at the time of settling down in the city occupy vacant lands near existing slums or other vacant lands to set up tents. Over time they settle down there and construct a slum house. They do not know who owns the vacant land at the time of settling down. A slum is usually less than a few hundred meters wide. Within this small area, it is difficult to ascertain which lands are tenable and which are untenable without access to detailed revenue department data. There is unlikely to be any selection by slum dwellers into tenable or untenable lands. In Figure 2 we see the distribution of tenable and untenable households within 1 slum. We see that the tenable and untenable households are interspersed with each other within the slum.

The slum dwellers living in the same slum are likely to face similar economic opportunities and environmental conditions. There is little variation across households within the same slum in access to employment opportunities and public services. Their relative location within the city is also the same. The slum dwellers in the same slum would also face a similar level of eviction threat. Evictions are usually implemented at the slum level rather than the individual household level. The slum dwellers living in tenable and untenable lands should have had a similar trajectory over time as well.

I test for similarity between households living in tenable and untenable lands in observables before the intervention. I estimate the coefficient β in the following equation

$$y_{is} = \beta \, tenable_{is} + \Gamma_s + \epsilon \tag{1}$$

where y_{is} is the outcome for household i in slum s before the implementation of these interventions; $tenable_{is}$ is a binary variable that is 1 if the household lives on a tenable land and 0 if they live on an untenable land; Γ_s are slum fixed effects. I calculate values of β that can be rejected by estimating this equation using ordinary least squares.

3.2 Data sources

3.2.1 Instrument data

The Government of Odisha conducted a drone based imaging of all slums across Odisha prior to the implementation of the tenure security intervention in 2017. They identified the areas occupied by the slum houses. They then mapped the households with the extent of the land occupied by them in a household survey. The drone images were also matched with the revenue records of the cities to determine the formal owner of the land. I use this data on the formal owner to classify households as living on tenable or untenable lands.[9] In the case of many households, their plot lies at the intersection of multiple revenue plots with different owners. In these cases I classify the household as tenable if more than half the house lies on tenable lands and as untenable otherwise. In the full sample 67% of households live on tenable lands.

[9] I classify as tenable lands where the Record of Rights is abandoned land (*anabadi* or *patita*), municipality (*pourasanstha*), reserved for public works (*sarbasadharana* or *rakshita*), animal husbandry (*gochar*), water department (*jalachar*), or health department. The untenable lands are those where the Record of Rights are names of private individuals, kings lands, railway departments, and forest department.

3.2.2 Pre-intervention data

The government conducted a household survey of all slum dwellers along with the drone imaging in 2017 prior to the distribution of tenure documents. In this survey the households were asked about the total annual household income, characteristics of their house, demographic details of all household members, and whether the family belongs to the economically weaker sections category. This data also includes the area of the land that the household occupies. I use this data to verify exogeneity of the instrument.

3.2.3 Outcomes data

I conducted a survey of these slum dwellers to measure outcomes 6 years after the start of the program to distribute tenure documents. The surveys were conducted in February-April 2023 and were administered in-person by enumerators. The sample included 5940 households from 201 slums across 11 cities in Odisha. I describe below the sampling strategy and subsequently the outcome measures.

I arbitrarily chose 11 urban local bodies out of 109 where the program intervention was underway. These include Balangir, Baripada, Bhawanipatna, Brajrajnagar, Dhenkanal, Jeypur, Jharsuguda, Keonjhargarh, Koraput, Malkanagiri, and Rairangpur. These towns had a population of 50,000 - 150,000. They are spread across the state as seen in Figure 1 and are representative of the different regions in the state.

There are 483 slums in all in these cities. I selected 201 slums from among these. I explain the process used to select slums in the Appendix Section 9.1. In all analysis in this paper we use slum fixed effects which renders the choice of slums moot. From each sample slum I selected 30 households at random for the survey. Some households could not be located due to the limited set of identifiers. In these cases I replace them with a different household. I present statistics about this replacement in the next sections.

3.2.4 Outcome measures

The primary outcome measure is the quality of the house the household is living in. In the survey we record many features about the house including the material of the roof, floor, wall, the number of windows, rooms, type of door, and type of electrical connections. I aggregate these individual measures of house quality using the first principal component of all variables. In the appendix I

also present results on two other definitions of indices. First, I regress the household's reported rent amount they would be willing to pay to live in their current house on all measures of house quality and use the coefficients from this regression to define a house quality index. Second, I regress the household's reported satisfaction with their house (on a likert scale) against the measures of house quality and use those coefficients estimated to define an index.

I also measure other outcomes of interest like household income, employment, consumption, health status, and household assets. However, I do not focus on these outcome measures in this paper because it is too early to observe treatment effects on these variables. I do still present these outcomes in the appendix.

In the survey I also conducted a behavioral experiment—I varied the level of benefits in the programs and asked households that if they were hypothetically offered the program would they take it up. This allows me determine the threshold level of benefits at which each household would accept the program.

3.2.5 Program implementation data

The tenure security program is implemented by the local government bodies. They maintain a record of all households who have received the tenure documents. I obtained this record as of Aug 2022 for all the cities in my sample. In the survey, I asked households what tenure documents do they have and record it as well. In the survey I also record their status of receiving the house construction grant, the stage of construction of the house, and the date on which they received the approval.

3.3 Estimation strategy

To analyse the incidence of the program and estimate the progressivity of the incidence, I determine household quintiles based on household income before the intervention. I then estimate the coefficients in this specification:

$$Y_i = \sum_{k=1}^{5} \eta_k \, \mathbb{1}\{quintile_i = k\} + \mu \, x_i^{BL} + \epsilon \tag{2}$$

where Y_i is an indicator for program take up, $quintile_i$ is the income quintile household i belongs to, and x^{BL} are other pre-intervention controls.

I estimate the causal impact of the house construction grant on outcome measures. I estimate

the ITT impact parameter as the coefficient in the specification

$$Y_{is} = \beta \; tenable_{is} + \Gamma_s + \mu \; x_{is}^{BL} + \epsilon \tag{3}$$

where Y_{is} is the outcome measure, $tenable_{is}$ is an indicator for household living on a tenable land, and Γ_s are slum fixed effects. x^{BL} is a subset of covariates from before the intervention selected using the double lasso procedure in Chernozhukov et al. (2015). I estimate the LATE parameter in the above specification replacing the indicator for tenable with an indicator for the receipt of the house construction grant instrumented for by the indicator for tenable land.

The treatment effect parameters estimate the impact on house quality at the time of the survey. While households are constructing a new house they live in other temporary arrangements sometimes of worse house quality. Some households had received the housing grant less than a year before the survey and hence were still constructing a house at the time of the survey. I also estimate the impact on house quality after the completion of construction. The subset of households receiving the house construction grant is likely endogenous with other outcome variables. However, the time at which they receive the grant is exogenous. The households apply for the house construction grant with the help of officials in the local government. The applications are reviewed at a central office and approvals are issued over time when funds are available. Households receiving the grants earlier are similar to the households receiving the grants later. To estimate the impact of house quality a year after receiving the grant, I drop from the sample all households who received the grant within the last one year and proportionately increase the weight on the households who received the grant more than a year before the survey.

3.4 Validity of the Research Design

3.4.1 Instrument exogeneity

In Table 1 I present the balance in covariates prior to the intervention for the subset of households surveyed at endline. We see that for most variables the difference in covariate values across tenable and untenable households are not statistically significant. I can reject differences greater than 3-5 percentage points for all house quality measures and greater than 10% of the mean for measures like household income. We also reject differences greater than 3 years for years since when the household has lived in that slum.

In Appendix Table 13 we see the balance in covariates across tenable and untenable households

among the set of all slum households in these 11 cities. We again see that the difference in covariate values across treatment and control households are not statistically significant. The larger sample size allows us reject even smaller treatment effects. We reject effects larger than 1pp for the house quality measures and effects larger than 0.05 sd for all other variables. This strongly suggests that the instrument used is exogenous.

In Appendix Table 14 we see that the households who received the grant earlier have similar covariates before the intervention as the households who received the grant later. I am not able to reject small differences due to the small sample size. However, the point estimates are similar in both groups. This suggests that the households receiving the grant later are a nearly random subset of all households receiving the grant.

3.4.2 Attrition

Attrition from the survey sample is one of the concerns in follow up surveys conducted nearly 5 years after the initial survey. The only identifiers from the census conducted by the government available with me are the names of the household members. This further reduces the probability of finding the houses. Attrition from the survey itself is not a concern but differential attrition across tenable and untenable households within the same slum can lead to biased estimates.

I consider the proportion of households who could be surveyed among the first 30 households selected in a slum. Many households could not be re-surveyed because we need to track them using their names and slum names alone. However, in Appendix Table 15 we see that the difference in probability of survey completion across tenable and untenable households is small and not statistically significant. The tenable households are slightly more likely to be missing in the survey. However, conditional on being in the same slum, this difference is small. The difference mainly seems to arise from a slightly higher probability of tenable households having migrated from the slum.

4 Results

4.1 Program Incidence

In Table 8 we see that program incidence is progressive. The probability of having received the program documents and taken up the program decreases from 25% among the poorest quintile to 15% among the richest quintile. This progressivity is marginally lower when we condition on house

quality at baseline. We see that households with a better house at baseline are much less likely to be receiving the benefits of the program. The incidence may be driven by household's preference to take up the program as well as the government's eligibility criteria and selection into the program.

To separate the effects of household preferences, we look at three preference measures in Table 9. We first see that conditional on being asked by a local government official to apply for the program, the probability that the households applies decreases by 5pp from the richest quintile to the poorest quintile. Second, in the survey I households were asked if they'd take up the program at the current level of benefits if offered to them. We see a decline in proportion of households responding yes from the poorest quintile to the richest quintile of about 5pp again. Third, in the survey we also vary the level of benefits in the program to identify at what level of benefits the household would be willing to take up the program. We see an increase in the threshold benefit level of Rs 35,000 or a 19% increase from the poorest quintile to the richest quintile. All these suggest that a significant part of the progressivity is driven by self-selection into the program by the poorer households.

This self-selection is likely not driven by their income but by the quality of their house prior to the intervention. Households receiving the benefits need to destroy their existing house to construct a new house. Those with worse quality houses hence face a lower opportunity cost. They are more likely to participate in the program. In all three measures of self-selection, we see that the progressivity along income decreases once we control for pre-intervention house quality. In fact we see no difference in the stated probability of taking up the program between the richest and poorest quintiles and the it is even a little regressive at lower income levels.

We do however note that the program incidence is progressive even conditional on pre-intervention house quality. This may be due to the additional filters placed by the government's eligibility criteria. This may also be because the house quality measures I observe are incomplete and the income is correlated with unobserved measures of house quality.

4.2 Treatment effects: First stage

Table 2 presents the first stage of the instrument. We see that according to the government records, 62% of all tenable households and 8% of all untenable households had received the tenure documents.[10] In the survey 29% of tenable households and 9% of untenable households reported

[10]Untenable households may receive tenure documents if the department gets the land transferred from the other departments. Some households living on municipality lands cannot receive tenure if there are public works planned there.

receiving tenure documents.[11] Accounting for the slum fixed effects, the first stage effect is 13.6pp and 41.4pp in these measures. We also see that 20% of tenable households and 4% of untenable households have received the first approval document for the house construction grant. This translates to a first stage effect of 10pp. The average tenable household has also received Rs 11,323 more than untenable households in the same slum.

Most households who have received the PMAY program have started construction of their house—9% households said they haven't started yet while another 4% say they don't plan to construct. 47% households reported still constructing their house and not living in the constructed structure. Most of these households had received the grant in the last one year.

4.3 Treatment effects

The primary outcome of interest is the endline house quality of the slum dwellers. In Table 5 we see that the ITT effect on the house quality index is 0.05sd and is statistically significant at the 10% level. In Appendix table 16 we see that the effect is similar with other definitions of the index as well. This ITT effect is driven by the effect on concrete roofs and brick walls primarily and we do not see any effect on other house components like cement floors and toilets.

Since the take up in the program is not complete, to interpret the treatment effects I look at the LATE estimate of those who have received the housing program. The LATE impact on the house quality index is 0.52σ. As an alternative measure I also estimate a propensity score to receive the program benefits as a function of all baseline covariates. I estimate that being in the tenable group and for a unit change in the propensity score the house quality index increases by 0.92σ.

In Table 6 we see the estimates of ITT estimates and the LATE estimates of the impact on individual components of house quality. We see a large statistically significant impact on the probability of having a concrete roof (LATE estimate of 60pp). We see no impact on probability of houses having a good asbestos roof or better which suggests that the households in the counterfactual that have asbestos roofs have concrete roofs because of the treatment. We see a reasonable sized effect, although not precisely estimated, on the probability of having brick walls and mud walls as well. We reject even modest sized impacts on all other parameters like better floors, having a toilet, safer electrical connections, or more windows and rooms.

It is instructive to separate the house quality measures into those verified and not verified. In the

[11] The difference between the households' report and the government records may be because the respondent is unaware of the documents or refers to it by some different name. The government records are as of Aug 2022 and the household reports are as of Feb-Apr 2023.

process of releasing the house construction grants, the local officials verify that the household has built a brick wall and a concrete roof. Receiving subsequent installments of the grant is contingent on this verification. There is no such incentive to improve their house along other dimensions. It could also cost them more to make such improvements. In the results we see impacts on the verified measures and no impacts on the other measures.

These treatment effects are the average effects of the program. However, there are likely to be heterogeneous treatment effects by time since when the household received the benefits. While constructing a house the households live in a temporary shelter with worse house conditions. After construction is complete they live in a better house. To separate these effects I employ two strategies. First I drop the households who have received the program benefits in the last one year and re-weight the households who have received before to account for this. We see in Table 5 that after such reweighting the ITT effect is 0.7σ and the LATE is 0.99 σ. In the second strategy I plot house quality as a function of time since when the households received the grant. The house quality index is normalized to have mean 0 for households living on untenable lands. We see in Figure 4 that the mean house quality drops to -0.4σ in the first year after receiving the grant and subsequently increases to 0.1σ a year later and 0.4σ two years later. Both these results suggest that the short-run treatment effects we measure here are lower due to the worse house quality the households experience during the construction phase. In the medium run we would expect the LATE on house quality to be 0.99σ.

In Table 7 we see the heterogeneity in the ITT effects in households belonging to different income quintiles. The treatment effects are larger among households in the poorest quintile and nearly zero for households in the richest quintile.

We saw above that the program has a statistically significant impact on house quality although along only a few dimensions. This can happen for two reasons: First, the program may have been incident on households who would have improved their house even in the absence of the program but they improved the house by more than what they would have without the grant. Second, the program may have been incident on those who would otherwise not have improved their house and the program leads to an improvement.

In Table 10 we see that among households living on untenable lands (and hence less likely to be affected by the intervention), conditional on pre-intervention house quality, higher income households improve their houses by a lot more than lower income households. The richest quintile households improve house quality by 0.34sd more than the poorest quintile households. However,

the program incidence is greater among lower income households. This suggests that the program is inducing those who would not have improved their house otherwise to do so.

But the program does not crowd in significant private investment. The poorer households do not have a lot of savings and would not be able to invest more money in the house than what they get from the grant. We see in Figure 5 that there is a moderate slope in the total expenditure on house construction as a function of household income before the intervention.

4.4 Mechanism: Impact of tenure security alone

The treatment effects estimated above are the combined effect of receiving tenure security documents and the house construction grant. We would like to separate the effect due to each program. Tenure documents can directly impact households in a few ways. First, households may perceive that they own the land and can sell the land and the house at any point. In Table 11 we see that less than 2% households believe they can sell the land they live on and this is marginally higher among those who live in untenable lands. We can conclude there is no wealth effect due to the treatment.

Second, households may be able to mortgage their tenure documents to raise money. In Table 11 we see that less than 0.5% of households even tried to mortgage their lands and an even fewer were successful in mortgaging their land. The tenure documents under the program are non-transferable. This reduces their value as a collateral.

Third, the tenure documents may reduce the households' perceived threat of eviction from the slum and encourage them to invest more in their house. We see in Table 11 that there is a statistically significant 5.5pp decrease in the perceived threat of eviction. To examine this further I present the difference in house quality between baseline and endline for households by whether they have received tenure documents and the house construction grant. Households who have received the house construction grant experience a 1.1σ improvement in house quality. But those who have only received the tenure documents and not the house construction grant experience a 0.45σ improvement in house quality which is similar in magnitude to the 0.39σ improvement among households who have not received either programs. While suggestive, this is not causal evidence since households select into the house construction program.

To estimate the causal effect I exploit the spillover effects of tenure security. Eviction usually happens at the level of a slum rather than a household. So even a household who does not themselves have tenure documents would experience reduced threat of eviction if the other households in the

slum receive tenure documents. However these spillover effects don't extend to the eligibility for the house construction grant. Hence if all the outcomes in endline house quality is driven by increased tenure security then we should see a large spillover effect in house quality as well.

To estimate this causally I use the variation in the share of a slum that is tenable across a city. In most slums we find a mix of tenable and untenable lands. However, this variation across slums and within a city is not entirely exogenous to the characteristics of the slum dwellers. I define a propensity score at the slum level for the proportion of the slum expected to live on tenable lands as a function of all baseline covariates. Sets of four slums with a similar propensity score are grouped together. All households in a group have similar characteristics at baseline. There is now variation at the household level on whether they live on tenable or untenable land and there is variation across slums on what proportion of slum dwellers live on tenable lands. We can estimate the spillover effects using the following specification:

$$\begin{aligned} Y_{isg} = \gamma_0 + \gamma_1\, tenable_{isg} \times (1 - share_tenable_{sg}) + \gamma_2\, tenable_{isg} \times share_tenable_{sg} \\ + \gamma_3\, (1 - tenable_{isg}) \times share_tenable_{sg} + \gamma_g + \gamma_4 \end{aligned} \tag{4}$$

where Y_{isg} is the individual level outcome, $tenable_{isg}$ is an indicator for whether that household lives on a tenable land, $share_tenable_{sg}$ is the share of households in slum s living on tenable lands, and γ_g is a group fixed effect.

In Table 12 we see the estimated coefficients for 5 different outcomes. The base group is households living on untenable lands in a slum where most households live on untenable households. We compare the outcomes in a slum where most households live on tenable lands (rows 2 and 3). We compare tenable households (row 2) and untenable households (row 3). In column 1 we see some effect of slum share living in tenable lands on receiving titles, but this effect (0.105) is about 35% of the effect on those living on tenable lands. However, in column 2 we see that the households living on tenable and untenable lands report nearly the same level of eviction threat. The spillover effect is 100% of the full effect. As expected we do not see a large spillover on grant receipt. The spillover effect on receiving the grant more than a year ago is 23% of the full effect. The spillover effect on house quality is 49% of the full effect. Hence at most 26% (which is 49pp - 23pp) of the total effect is the spillover effect which may be due to the reduced eviction threat alone.

5 Theoretical framework

I provide a theoretical framework to study transfer programs with a large deadweight loss. I first use the framework to understand who select into taking-up the program. This framework is also useful to understand the impact of the transfer on household welfare. The magnitude of welfare benefits due to the program are ambiguous—there can be multiple recipients of the transfer program and yet the welfare benefit to each of them small. One of the challenges is measuring the welfare benefits. From the households' revealed preference to take-up or not take-up the program we can infer the sign of the welfare benefits they receive. I show that under reasonable assumptions this take-up decision is a sufficient statistic for the aggregate welfare transferred. This is similar to a Roy model. I then use this framework to estimate the optimal benefit levels in the program. The optimal benefit levels would maximize the welfare transferred to the households (net of deadweight loss). This requires us to trade off the distribution of the deadweight loss in the population, the selection into taking-up the benefits, and the concavity of the utility function. I use the data from the program to calibrate the model and qualitatively discuss the optimal benefit levels in the program.

5.1 Setup

Consider the household problem. The household has an income I_i and house quality h_i to start with. In the status quo the household allocates some of its income to purchase a consumption good c_i and some of its income to improve their house $hnew_i$.[12] After these transactions let the household's value function of maximum utility attained be denoted by $u_n(h_i, I_i)$.

Suppose the government introduces a housing grant. Let the total budget of the government be B.[13] Let the grant amount for each recipient be b. To receive the benefits of the grant, the household has to construct a house of quality at least H^{req}. The grant amount may not be sufficient to construct such a house. The households would have to supplement the grant with money from their savings or a loan to construct. I denote the value function of the maximized utility attained by the household if they choose to participate in the program as $u_y(I_i, h_i, b, H^{req}) + \lambda_{yi}$. The

[12] I assume a static one period model where households start with an endowed house and choose to add investments to it. I assume the time period is large enough so that the house depreciates completely at the end of the period. This is done to keep the model simple. I assume the housing good is measured in the same units as consumption and ignore prices

[13] I assume the government has an exogenously determined fixed budget B for the program independent of the program parameters. This is the appropriate assumption in developing countries where the beneficiaries of such programs are often not the tax-payers and hence their actions do not affect the total budget available.

households need to break down their existing house and construct afresh if they are participating in the program. Hence the utility attained is the same irrespective of initial house quality. λ_{yi} is an idiosyncratic preference term. There may be dimensions of house quality that are not captured in h_i. Households with different demographic structure may have different preferences over house quality and structure. Heterogeneity in preferences along such dimensions would be captured in λ. I use the shorthand u_{yi} and u_{ni} for $u_y(I_i, h_i, b, H^{req})$ and $u_n(h_i, I_i)$ respectively. I make the following assumptions about the utility functions:

Assumption 1. *1. Conditional on taking up the grant, the current quality of house does not affect the utility gained:* $\frac{du_{yi}}{dh_i} = 0$

2. The value functions are increasing in the input parameters: $\frac{\partial u_{ni}}{\partial I_i} \geq 0$, $\frac{\partial u_{yi}}{\partial I_i} \geq 0$, $\frac{\partial u_{ni}}{\partial h_i} \geq 0$, $\frac{\partial u_{yi}}{\partial b} \geq 0$

3. The heterogeneity in preferences is distributed according to a logistic distribution: $\lambda_{yi} \sim$ *logistic*$[0, \beta]$

The first assumption follows from the households having to breakdown their existing house to receive the house construction grant. Hence the utility attained is the same irrespective of the house quality they start with. [14] The second assumption only assumes the utility function is increasing in all inputs. The main assumption I make is that λ_{yi} has a logistic$[0, \beta]$ distribution in the population. The parameter β is proportional to the standard deviation of the distribution and is a measure of the heterogeneity in preferences. The logistic distribution is commonly used to represent a choice between two alternatives as in the logit model. Trade models also model individual choices using similar extreme value distributions.

5.2 Take-up decisions

Assuming each household is making an optimal choice, a household chooses to take up the benefits in the program if $u_{yi} + \lambda_{yi} > u_{ni}$ and they do not otherwise. We can now compute the probability that a household with household income I_i and prior house quality h_i would take up the benefit. Since u_{yi} and u_{ni} are deterministic the expectation is only over the distribution of λ_{yi}.

[14] I assume that the cost of destroying a house is the same irrespective of current house quality. There may be different costs of breaking down a concrete house and a house made of bamboo but since this difference is likely small I ignore such differences here.

Proposition 1. *The probability $p(H_i, I_i)$ that a household with income I_i and house quality h_i takes up the benefit is given by*

$$p(H_i, I_i) = \frac{e^{u_{yi}/\beta}}{e^{u_{yi}/\beta} + e^{u_{ni}/\beta}} = \frac{1}{1 + e^{(u_{ni} - u_{yi})/\beta}} \tag{5}$$

The proof of this proposition follows from the properties of logistic distribution. We can also interpret this as the share of households with income I_i and house quality h_i that choose to take up the benefits of the program. To simplify notation, I will use the shorthand p_i for $p(h_i, I_i)$. We first note some important characteristics of this take up probability under standard assumptions about u_{yi} and u_{ni}

Proposition 2. *1. p_i decreases as current quality of house increases holding income fixed*

$$\frac{\partial p_i}{\partial h_i} \leq 0$$

2. p_i increases with benefit levels in the program

$$\frac{\partial p_i}{\partial b} \geq 0$$

3. If $p_i > 0.5$, the partial derivative of p_i with respect to h_i decreases in magnitude with increase in the benefit level in the program b.

$$\frac{\partial^2 p_i}{\partial b \partial h_i} > 0 \text{ if } p_i > 0.5$$

The first part of the proposition states that the take up probability decreases as the prior house quality increases. Those living in worse houses are more likely to take up the benefits of the program. The second part shows that conditional on house quality, the take up probability increases as the program becomes more generous. The third part shows that as the program becomes more generous, the progressivity in the take up probability decreases.

The gradient of program take up with respect to income is ambiguous. This depends on whether the grant substitutes existing household expenditure on housing or it crowds in additional expenditure on housing. However, if house quality and household income are strongly correlated then it is more likely that the take up probability would decrease with income. We see this in the expression below:

$$\frac{dp_i}{dI_i} = -p_i^2 \times e^{(u_{ni}-u_{yi})/\beta} \times \left(\frac{\partial u_{ni}}{\partial I_i} - \frac{\partial u_{yi}}{\partial I_i} + \frac{\partial u_{ni}}{\partial h_i}\frac{dh_i}{dI_i} \right)$$

These propositions present how self-selection into the program varies with household characteristics. Households with worse house quality at baseline are more likely to select into the program. But as the program generosity increases the degree of self-selection decreases. We observe these properties in the data from the program as well. As discussed in Section 4 the share of households applying for the program decreases with baseline house quality. This also translates into a decrease in take up with baseline household income. From the survey experiment we also have the share of households willing to take up the program at different levels of program benefits. In figure 6 we see that while the probability of households wanting to take up the benefit decreases with income, the slope is more negative at lower levels of the benefit and becomes flatter as the benefit level increases.

5.3 Welfare

We are interested in estimating the welfare transferred to the household as a result of the program. I define welfare as the difference in utility attained by a household when they are offered the house construction grant and when they are not. The welfare gain for household i is given by

$$W_i = \max(u_{yi} + \lambda_{yi} - u_{ni}, 0) \tag{6}$$

This welfare gained is the intent-to-treat or ITT effect on welfare. For households who stand to lose from taking up the program and hence would not take up the program the ITT effect is 0. For households who would take up the program the welfare effect is the difference in utility levels attained. This is the policy relevant parameter on which a government would base their decision to introduce the program. Note that this definition of welfare assumes that any household who would like to receive the house construction grant gets it. In practice there may be fiscal constraints that limit the total number of grants that can be handed out. I account for these later in this section.

From equation 5 we have

$$u_{yi} - u_{ni} = \beta \log\left(\frac{p_i}{1-p_i}\right) \tag{7}$$

Using this, we can estimate the expected welfare transferred to any household.

Proposition 3. *Under assumption A3, the expected welfare transferred to a household with income*

I_i and house quality h_i is given by

$$W(h_i, I_i) = \beta \log\left(\frac{1}{1-p_i}\right) \tag{8}$$

Proof. See Appendix. ■

This is the expected welfare transferred to a household of income I_i and house quality h_i. By the law of large numbers this is also close to the average welfare transferred to all households with the same I_i, h_i. The theorem above states that the average welfare transferred is only a function of the probability of participating in the program and β. Thus (p_i, β) is a sufficient statistic for the average welfare benefits of the program for all households with income I_i and house quality h_i. This is independent of the functional form of the utility functions and the house requirements under the grant and only depends on the distribution of the idiosyncratic preference shocks. [15]

Now we consider the policy relevant statistic of welfare benefits transferred per dollar spent. Suppose the government budget is B and the benefit level to each beneficiary is b. Let N_i be the number of households with income I_i and house quality h_i. Let us first assume that the entire population have a fixed income and house quality (I_i, h_i). Then the expected number of households applying for the grant would be $p_i N_i$. The government can hand out only B/b grants. If $B/b < p_i N_i$ I assume that they randomly select B/b households who apply for the benefit and hand the grants to them.[16] Thus the probability that a household applying for the grant gets it is $\frac{B}{bN_i p_i}$.

The average welfare transferred given this probability of success is

$$W(h_i, I_i, B, b) = \frac{B}{bN_i p_i} \beta \log\left(\frac{1}{1-p_i}\right) \tag{9}$$

Now we consider households with varying (I_i, h_i). There is a different take up probability p_i for each type of household. The total number of households applying for the grant is equal to $\sum_{i=1}^{N} p_i$. The total welfare transferred is equal to

$$W(B, b) = \frac{B}{b\sum_{i=1}^{N} p_i} \sum_{i=1}^{N} \beta \log\left(\frac{1}{1-p_i}\right) \tag{10}$$

[15] This formula is also analogous to the ACR formula for welfare gained from trade. There the welfare gained is expressed as function of the spread parameter of the idiosyncratic shocks and the own share of trade. The take up probability is the equivalent of the own share of consumption in this setting.

[16] Governments try to award grants to all who demand them. But in practice only a share of the population receive such benefits. Lotteries are a common mechanism used in allotting benefits in housing programs. Due to data limitations governments are not able to target specific characteristics. The assumption here captures a lottery.

This is a formula for the aggregate welfare benefits transferred to all households when the program parameters are set as here. We can use this to study how the aggregate welfare varies with the program parameters.

5.4 Optimal benefit level

The benefit level in the program b is the amount each beneficiary receives. Since we hold the total budget B fixed, this also determines the number of beneficiaries B/b. This affects the total dead weight loss in the program. The benefit level also determines the household's probability of selecting into applying for the program. The combination of these factors influence the aggregate welfare transferred. I will discuss intuitively how increasing benefit level affects welfare and then numerically estimate these gains.

Consider first a homogeneous population who receive a utility of u_n in the status quo and receive a utility $u_y(b)$ if they take up the program. Since all households are maximizing their utility, they will take up the program iff $u_y(b) > u_n$. If the benefit level is set such that $u_y(b) = u_n + \epsilon$ for a small value ϵ. Then a large share of the population will receive the benefits. However, the net welfare transferred to the households would be negligible since most of the benefits are spent on offsetting the "deadweight loss" of u_n. However, if we allocated the entire budget on one household and set $b = B$, then due to the concavity of u_y as a function of b or the diminishing marginal returns of the grant, the aggregate welfare benefits need not be maximized. Hence there is an optimal level of b^* that trades off the concavity of u_y and the dead weight loss in the program. Note that this is a feature of such programs with a dead weight loss. If there were no participation costs, then the optimal benefit level would be set such that all households receive the program.

Now consider a population with two types of of people L and H accounting for half the population each. The L type have a poor house quality at baseline and receive a utility of u_n^L in the status quo. H type have a better house quality at baseline and receive a utility of $u_n^H (> u_n^L)$ in the status quo. Let the two types of households be identical in all other respects. Let the utility they receive if they take up the program be $u_y(b)$ for both types of households. The trade-off between diminishing marginal returns and offsetting the deadweight loss exists in this case as well. In addition, the optimal benefit level also needs to account for the heterogeneous selection into the program. Suppose $u_y(b^*) = u_n^H$. For some small ϵ, if the benefit level is set to $b^* - \epsilon$, then only the L type of households apply for the grant. The deadweight loss for all participating households is relatively low and the welfare benefit to each household receiving the program is $u_y(b^*) - u_n^L$.

If instead the benefit level is set to $b^* + \epsilon$, then both the L and H type households apply for the benefits. Since the grant is allotted at random among the applicants, for the half the recipients (L type) the deadweight loss is low and the welfare benefit is $u_y(b^*) - u_n^L$. For the other half of the recipients (H type) the deadweight loss is high and the welfare benefit from the program is ϵ. Hence the aggregate welfare transferred would discontinuously decrease at b^*. The optimal transfer value could be some value that sets u_y between u_n^L and u_n^H (separating equilibrium) or at some value greater than u_n^H (pooling equilibrium) depending on the parameter values.

We generalize this further to include an idiosyncratic utility shock when the individual takes up the program distributed with a logistic distribution. This smooths the selection into applying for the program and the deadweight loss among the recipients. In addition, there may be other factors varying with the baseline house quality, like income. This in turn can affect the magnitude of $u_y(b)$ through the elasticity of substitution between consumption and housing. To determine the optimal benefit level in the program we need to account for the concavity of the utility function, the deadweight loss among the recipients, the selection of people into applying for the program, the distribution of the idiosyncratic shock, and the elasticity of substitution between consumption and housing.

To numerically estimate the optimal benefit level we need to estimate the take up rates at each benefit level. We can calibrate a structural model to estimate the take up and welfare at different benefit levels. Consider households with a cobb douglas utility function $u = log(c_i) + \alpha log(h_i)$. They have an income I_i and prior house quality H_i. In a given period the household may spend their income on buying consumption goods or additional housing. However, if they spend on housing then they need to pay a fixed cost of η.[17]

The household problem without the program is given by

$$\max_{c_i, h_i} \log(c_i) + \alpha \log(h_i)$$

$$I_i = c_i + hnew_i + \eta \mathbb{1}(hnew_i > 0)$$

$$h_i = H_i + hnew_i$$

$$c_i \geq 0$$

$$hnew_i \geq 0$$

[17] I assume a period length of 10 years which is a duration in which most of these houses would depreciate completely. Hence I model housing as a consumption good rather than as an investment.

The value function is given by

$$u_n^{(ii)}(I_i, H_i) = \max\{\log(I_i) + \alpha \log(H_i), \log(I_i - hnew_i^* - \eta \mathbb{1}(hnew_i^* > 0)) + \alpha \log(H_i + hnew_i^*)\}$$
$$hnew_i^* = \max\{0, \frac{\alpha I_i - H_i - \alpha\eta}{1+\alpha}\}$$

Now suppose the households participate in the program. They receive a grant b that they must use to construct a house of quality at least H^{req}. They destroy their existing house of quality H_i and construct a new house. The household problem if they take up the program is given by

$$\max_{c_i, h_i} \log(c_i) + \alpha \log(h_i)$$
$$I_i + b = c_i + hnew_i + H^{req} + \eta$$
$$h_i = H^{req} + hnew_i$$
$$c_i \geq 0$$
$$hnew_i \geq 0$$

In some cases the household may not be able to afford the construction of the house and keep consumption positive. In such cases we set the maximized value to $-\infty$ so that the corresponding take up probability is 0. The maximized utility value function is given by:

$$u_y^{(ii)}(I_i, H_i) = \begin{cases} \log(I_i + b - H^{req} - hnew_i^* - \eta) + \alpha \log(H^{req} + hnew_i^*) & \text{if } I_i + b - H^{req} - \eta \geq 0 \\ -\infty & \text{if } I_i + b - H^{req} - \eta < 0 \end{cases}$$
$$hnew_i^* = \max\left(0, \frac{\alpha(I_i + b - H^{req} - \eta) - H^{req}}{1+\alpha}\right)$$

We see that this maximized utility value does not depend on H_i. A household will choose to take up the benefits of the program if $u_y + \lambda_y > u_n$ and will not otherwise. Hence the probability a household takes up the grant is still given by p_i as before. I estimate the welfare benefits by calibrating this model and numerically estimating the welfare transferred at different benefit levels b for the survey sample using the result in Equation 10.

I calibrate this model to the data from the survey. I set the duration of the time period to be 10 years. We need to convert the house quality index into the same units as income. I use the households' reported willingness to pay rent for that house. I calculate the rent they'd be willing

to pay to live in that house for 10 years. I also estimate the house quality of a house that meets the program requirements to set H^{req}—the minimum quality of house all recipient households have to build. I estimate the substitutability of house and consumption, α, and the fixed cost η using the observed expenditure on housing among the non-tenable households. Finally I estimate β using the slope of stated probability to take up the program by baseline house quality and income. I detail the calibration process in the appendix.

We see in Figure 7 the welfare levels estimated at different benefit levels. We see in Figure (a) that increasing the benefit level by a little would decrease the aggregate welfare benefits. This happens because a large number of households with a high deadweight loss select in to take up the benefits. This increases the aggregate dead weight loss. However, increasing the benefit level by a lot considerably increases aggregate welfare. This happens because at those high levels, the benefit exceeds the money needed to construct a house of quality H^{req} and the households can spend the benefits on consumption as well. In figure (b) households are weighted by welfare weights inversely proportional to their baseline income quintiles. A key difference we see here is that the current benefit level is at a local minima of the welfare curve. At the current benefit level many poor households do not take up the benefits because they cannot afford the complementary expenditure needed to construct a house. Increasing the grant value will allow them to take up the benefits and increasing the aggregate welfare transferred.

6 Discussion

Improving housing conditions in slums is an important policy goal for all developing countries. With increasing rural to urban migration, the scale of the problem is only set to increase. Policymakers have adopted a range of housing programs to address this problem including subsidised sale of serviced plots, rent subsidies, and provision of house construction materials. However, it has been a challenge to target such benefits at the poor. They are often unable to afford public houses or plots even at a subsidised price. Further, slum dwellers value the economic networks they have built in the city and are unwilling to take up even free houses on the periphery. By contrast, in this paper we see the housing program having a high take up and large impacts on house quality.

The incidence of the program is progressive. Households in the lowest income quintile are 10pp more likely to be beneficiaries of the program than households in the highest income quintile. This is driven by the poor self-selecting into the program. The outside option to these households is the

quality of their current house. This is similar to the self-selection observed in programs like work fare where the outside option is their current job or school voucher programs where the outside option is the quality of the school the student currently attends.

The impact of the program on short term house quality is large, driven primarily by having a concrete roof and brick walls. Having a concrete roof will help slum dwellers protect themselves from rain and storm. Usually slum houses get inundated with water during rains. This can be disruptive to the family. Stagnant water makes them more susceptible to communicable diseases like diarrhoea. This can also damage any assets they have at home. Besides this, households also experience pride and intrinsic pleasure in having a formal house of their own.

The transfers in this program are large—they are equal to two times the annual household income. Despite that, we do not see a large improvement in the other measures of house quality. The large deadweight loss in this program reduces the value of the transfer to the households. This in turn also reduces the aggregate welfare benefit from the program. This is a problem common to all infrastructure projects where marginal improvements over time are often not feasible and improvements require a large upfront investment.

The observed improvements in house quality can have many downstream effects. Marx et al. (2013) suggest slum dwellers may be stuck in a poverty trap due to poor quality housing. With improved housing, the household members may enjoy better health status; they may invest in more assets like electronic appliances; they may use their house to start households businesses like tailoring shops or small grocery stores. At the time of this study the households had just completed the construction of their houses. It would be informative to look at these outcomes in a follow up survey.

7 Tables

Table 1: Balance table

	Untenable		Tenable				
	n	mean	n	mean	Diff	Confidence interval	p-value
Plot chars							
Occupied area (sqft)	1814	497.13	4103	507.10	16.500	-8.082 - 41.083	0.19
Area per person (sqft)	1814	189.71	4103	190.78	-1.826	-14.493 - 10.840	0.78
Income							
Annual income (IHS)	1809	8.28	4088	8.23	-0.042	-0.164 - 0.079	0.50
Annual Income (winsorized)	1814	58878.10	4100	58644.11	-79.078	-3,706.236 - 3,548.081	0.97
Income per capita (Rs)	1814	20850.15	4103	21839.25	-653.306	-2,297.794 - 991.181	0.44
House quality							
Permanent roof	1814	0.06	4095	0.10	-0.003	-0.024 - 0.018	0.76
Brick wall	1814	0.53	4101	0.60	0.012	-0.023 - 0.047	0.51
Toilet in house	1814	0.33	4100	0.33	0.008	-0.025 - 0.040	0.64
Direct access to road	1814	0.75	4101	0.68	0.022	-0.006 - 0.051	0.12
Demographics							
HH size	1814	3.29	4103	3.31	0.108	-0.001 - 0.217	0.05
Number of children	1814	0.93	4103	0.94	0.088	0.002 - 0.174	0.04*
Average household age	1814	33.39	4103	33.38	-0.971	-2.087 - 0.146	0.09
Proportion female	1814	0.51	4103	0.50	-0.017	-0.035 - 0.002	0.08
Education							
Highest adult edu	1704	6.68	3877	6.91	0.080	-0.300 - 0.461	0.68
Mean adult edu	1692	4.95	3858	5.16	0.110	-0.207 - 0.427	0.50
Caste							
Advantaged caste	1759	0.21	4001	0.21	-0.013	-0.043 - 0.017	0.38
SC caste	1759	0.25	4001	0.29	0.023	-0.008 - 0.053	0.14
ST caste	1759	0.32	4001	0.26	-0.005	-0.036 - 0.025	0.73
Migration							
Years in slum	1798	58.91	4066	54.19	0.805	-1.458 - 3.067	0.49

Notes. The sample includes all households surveyed in the endline. The first 4 columns present the mean and number of observations for individuals in tenable and untenable lands respectively. The last three columns present the coefficient of regressing the outcome on the tenability of the land with slum fixed effects, the 95% confidence interval, and the p-value. We can reject differences between the two groups larger than the confidence intervals.

Table 2: First stage: Program receipt

	Received tenure		PMAY	
	(1) Self-report	(2) Govt record	(3) Received	(4) Money rcd (Rs)
Tenable	0.136***	0.414***	0.0989***	11323.1***
	(0.0144)	(0.0151)	(0.0110)	(1677.8)
Untenable mean	0.09	0.08	0.04	5480.13
Tenable mean	0.29	0.62	0.20	24604.20
Slum FE	Yes	Yes	Yes	Yes
N	5824	5876	5915	5903

Notes. This table presents the impacts of the intervention on program receipt. The coefficients estimated are those in equation 4 estimated using OLS. The dependent variables are the household's report of whether they have received tenure documents, the government's records of whether they have received tenure documents (as of Aug 2022), whether the household has received any benefits under the house construction grant, and the amount of money received per household (unconditional on program receipt). The mean of all tenable and untenable households is also presented. The raw difference is different from the treatment effect coefficient due to the slum fixed effects. All regressions include slum fixed effects and a selected subset of pre-intervention covariates.

Table 3: ITT Impact on House Quality

	House quality index	House quality components			
	(1)	(2) Concrete roof	(3) Brick wall	(4) Cement floor	(5) Toilet
Tenable	0.0532*	0.0592***	0.0166	-0.00529	-0.00387
	(0.0323)	(0.0140)	(0.0170)	(0.0158)	(0.0161)
LATE of grant receipt	0.523	0.594***	0.175	-0.0434	-0.0217
	(0.329)	(0.152)	(0.169)	(0.154)	(0.168)
Untenable mean	0.00	0.14	0.66	0.71	0.33
Slum FE & BL controls	Yes	Yes	Yes	Yes	Yes
N	5908	5915	5915	5915	5915

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table presents treatment effects of the house construction grant on the house quality index and components of the index. The dependent variables are the house quality index defined as the principal component of all individual measures and indicators for whether the house has a concrete roof, brick wall, cement floor, and toilet in the house. The estimates are coefficients from specification 4. All results are the ITT results. All regressions include slum fixed effects and baseline controls.

Table 4: LATE impact on House Quality

	House quality index		House quality components			
	(1)	(2)	(3) Concrete roof	(4) Brick wall	(5) Cement floor	(6) Toilet
Received PMAY	0.523		0.594***	0.175	-0.0434	-0.0217
	(0.329)		(0.152)	(0.169)	(0.154)	(0.168)
Tenable		-0.0800				
		(0.0630)				
Tenable × Propensity score		0.920**				
		(0.370)				
Slum FE & BL controls	Yes	Yes	Yes	Yes	Yes	Yes
N	5908	5756	5915	5915	5915	5915

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

First column and last four columns of this table presents LATE of the house construction grant on the house quality index and the individual components. The dependent variable is the house quality index defined as the principal component of all individual measures. The estimates are coefficients from the 2SLS specification with program receipt instrumented for by tenability. In the second column I regress the house quality index against an indicator for living in tenable lands and the indicator interacted with a propensity score for taking up the program. The propensity score is the best linear predictor of take up as a function of all baseline covariates. All regressions include slum fixed effects and baseline controls.

Table 5: Impact on House Quality adjusted for construction phase

	House quality index			
	(1) ITT	(2) LATE	(3) ITT	(4) LATE
Tenable	0.0532		0.0672*	
	(0.0323)		(0.0336)	
Received PMAY		0.523		0.990*
		(0.329)		(0.500)
Reweighted	No	No	Yes	Yes
Slum FE & BL controls	Yes	Yes	Yes	Yes
N	5908	5908	5464	5464

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table presents treatment effects of the house construction grant on the house quality index. The dependent variable is the house quality index defined as the principal component of all individual measures. The estimates are coefficients from specification 4. The first two columns are unweighted regressions and the last two columns down-weight households still constructing the house. All regressions include slum fixed effects and baseline controls.

Table 6: Impact on components of house quality

	Untenable	Tenable	ITT	Confidence interval	p-value	IV
Targeted measures						
Roof						
Concrete	0.14	0.25	0.058	0.028 - 0.089	0.00***	0.597***
Tiled	0.30	0.37	0.038	0.003 - 0.073	0.03*	0.386*
Good asbestos	0.71	0.72	-0.012	-0.046 - 0.023	0.51	-0.118
Bad asbestos	0.97	0.96	0.005	-0.009 - 0.019	0.49	0.050
Wall						
Brick	0.66	0.69	0.022	-0.013 - 0.056	0.21	0.223
Mud	0.86	0.87	0.026	-0.000 - 0.052	0.05	0.264
Metal/asbestos	0.97	0.96	0.009	-0.005 - 0.023	0.19	0.095
Non-targeted measures						
Painted walls	0.55	0.56	0.012	-0.024 - 0.048	0.52	0.122
Floor						
Tiles	0.05	0.07	0.012	-0.007 - 0.031	0.21	0.124
Cement	0.71	0.75	-0.000	-0.032 - 0.032	0.99	-0.002
Toilet						
In-house w water	0.15	0.18	-0.000	-0.029 - 0.028	0.99	-0.002
In house	0.33	0.33	0.000	-0.034 - 0.034	0.99	0.002
Exclusive	0.52	0.57	0.018	-0.016 - 0.052	0.30	0.184
Shared	0.57	0.60	0.024	-0.009 - 0.058	0.15	0.250
Other features						
Door with latch	0.86	0.86	0.012	-0.014 - 0.037	0.37	0.120
Concealed wires	0.39	0.45	0.019	-0.018 - 0.055	0.32	0.191
Num windows	1.35	1.57	0.022	-0.094 - 0.137	0.71	0.219
Num rooms	2.74	2.75	-0.047	-0.152 - 0.058	0.38	-0.482
Theft threat	0.18	0.17	-0.010	-0.040 - 0.019	0.49	-0.107
Problems during rain						
Roof not leaking	0.27	0.30	0.024	-0.012 - 0.059	0.19	0.243
Door not leaking	0.52	0.49	0.004	-0.034 - 0.043	0.82	0.046
Wall not leaking	0.51	0.49	-0.009	-0.048 - 0.030	0.65	-0.091
No water logging	0.85	0.84	0.031	0.004 - 0.059	0.03*	0.320*

Notes. The first two columns are the raw means of households living on untenable and tenable lands respectively. The third column is the ITT estimate from specification 4 and the fourth and fifth columns are the corresponding 95% CI and p-value. The last column is the LATE of the house construction grant. For variables about roof, wall, and floor, the values are cumulative. The row title should be read as "Does the house have a tiled roof or better material roof?". For the problems faced by the households during rains, the values are the proportion of households reporting facing this problem. These questions have been inverted so that for all variables a higher value can be interpreted as a better quality house.

Table 7: Heterogeneous treatment effects by income

	(1) Recd tenure documents	(2) Recd house grant	(3) House quality index	(4) House quality index
Tenable × BL Inc quintile: 1	0.421***	0.141***	0.135**	0
	(0.0216)	(0.0220)	(0.0646)	(.)
Tenable × BL Inc quintile: 2	0.398***	0.105***	0.0541	-0.0805
	(0.0222)	(0.0227)	(0.0665)	(0.0856)
Tenable × BL Inc quintile: 3	0.390***	0.101***	0.0476	-0.0870
	(0.0185)	(0.0188)	(0.0551)	(0.0773)
Tenable × BL Inc quintile: 4	0.427***	0.0608**	0.0476	-0.0871
	(0.0251)	(0.0254)	(0.0746)	(0.0927)
Tenable × BL Inc quintile: 5	0.451***	0.0635***	0.00991	-0.125
	(0.0238)	(0.0243)	(0.0713)	(0.0904)
Tenable				0.135**
				(0.0646)
BL Inc quintile: 1	0	0	0	0
	(.)	(.)	(.)	(.)
BL Inc quintile: 2	0.0333	0.0150	0.125*	0.125*
	(0.0242)	(0.0247)	(0.0723)	(0.0723)
BL Inc quintile: 3	0.0178	0.00224	0.202***	0.202***
	(0.0218)	(0.0222)	(0.0650)	(0.0650)
BL Inc quintile: 4	0.0117	0.0264	0.259***	0.259***
	(0.0258)	(0.0262)	(0.0768)	(0.0768)
BL Inc quintile: 5	-0.0177	-0.00984	0.685***	0.685***
	(0.0255)	(0.0260)	(0.0763)	(0.0763)
Constant	0.157***	0.0772***	-0.188***	-0.188***
	(0.0175)	(0.0179)	(0.0524)	(0.0524)
Slum FE	Yes	Yes	Yes	Yes
N	5876	5915	5908	5908

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes. This table presents results from regression of outcomes against baseline income quintiles and interaction of the quintiles with indicator for the tenable instrument. The dependent variable in the first column is the government record of whether the household received tenure documents, the second column is indicator for whether the household received the house construction grant, and in the third column is the endline house quality index. All regressions include slum fixed effects.

Table 8: Program Incidence by Income

	Program taken up	
Income quintiles		
1	0	0
	(.)	(.)
2	-0.0435*	-0.0371
	(0.0193)	(0.0190)
3	-0.0604***	-0.0517**
	(0.0178)	(0.0176)
4	-0.104***	-0.0898***
	(0.0222)	(0.0219)
5	-0.0944***	-0.0768***
	(0.0205)	(0.0205)
Roof		
Concrete		-0.102***
		(0.0259)
Tiled		-0.0359*
		(0.0171)
Asbestos		-0.142***
		(0.0188)
Wall		
Brick		0.0271
		(0.0149)
Mud		-0.113***
		(0.0264)
Toilet		-0.0314*
		(0.0136)
Constant	0.248***	0.482***
	(0.0139)	(0.0308)
N	4103	4103

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. The dependent variable is an indicator for whether the household has taken up the program. A household is considered to have taken up the program if they have received the documents approving their receipt of the house construction grant and they are constructing/plan to construct a house to get the benefits of the program. The income quintiles are computed using the full distribution of household income in the census conducted prior to the intervention. The regression specification in the second column controls for characteristics of the house before the intervention. The sample is restricted to households living in tenable lands.

Table 9: Self-selection in take up of program

	Applied | Selected		Intend to take up		Threshold benefits level	
Income quintiles						
1	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
2	-0.0158	-0.0142	0.0118	0.0205	-682.1	-4119.1
	(0.0273)	(0.0273)	(0.0187)	(0.0185)	(6967.4)	(6858.8)
3	-0.0726**	-0.0696**	0.0122	0.0248	-3686.8	-9160.3
	(0.0248)	(0.0249)	(0.0170)	(0.0169)	(6343.3)	(6257.1)
4	-0.0408	-0.0276	0.00294	0.0203	1469.4	-6253.5
	(0.0319)	(0.0318)	(0.0208)	(0.0206)	(7766.7)	(7650.1)
5	-0.0496	-0.0380	-0.0454*	0.00601	35065.6***	12477.2
	(0.0310)	(0.0312)	(0.0197)	(0.0199)	(7329.7)	(7380.1)
Roof						
Concrete		-0.144**		-0.0487		31962.1***
		(0.0487)		(0.0256)		(9520.4)
Tiled		0.0844***		0.00830		-10776.8
		(0.0250)		(0.0161)		(5976.9)
Asbestos		-0.0934***		-0.0274		19156.9**
		(0.0256)		(0.0184)		(6848.6)
Wall						
Brick		0.0134		-0.0487***		22510.1***
		(0.0210)		(0.0141)		(5246.1)
Mud		-0.0567		-0.0516		9456.8
		(0.0374)		(0.0280)		(10406.3)
Toilet		-0.0401		-0.126***		48822.3***
		(0.0206)		(0.0131)		(4866.1)
Constant	0.820***	0.935***	0.709***	0.835***	189084.8***	142583.6***
	(0.0190)	(0.0429)	(0.0132)	(0.0319)	(4912.1)	(11859.2)
N	2113	2113	5917	5917	5917	5917

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. The dependent variable in the first two columns is 1 if the household applied for the program and 0 otherwise. The sample in the first two columns is restricted to those offered the program by the government. The dependent variable in the next two columns is an indicator for whether the household reports in the survey that they would be interested in taking up the program at the current benefit levels if offered to them. The dependent variable in the last two columns is the threshold level of benefits at which the household would be willing to take up the program. The income quintiles are computed using the full distribution of household income in the census conducted prior to the intervention. The regression specification in the even columns controls for characteristics of the house before the intervention.

Table 10: Improvements in house quality by income quintile

	Improvement in house quality	
Income quintiles		
1	0	0
	(.)	(.)
2	0.0479	0.108
	(0.0802)	(0.0679)
3	0.128	0.207***
	(0.0706)	(0.0599)
4	0.0466	0.102
	(0.0831)	(0.0704)
5	0.0430	0.342***
	(0.0824)	(0.0722)
N	1814	1814
BL House controls	No	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. The dependent variable is the difference in house quality index value in the survey after the intervention and in the census before the intervention. The first column presents results from regressing the dependent variable against indicators for the 5 income quintiles. In the second column I include controls for house quality before the intervention. The sample is restricted to households living on untenable lands.

Table 11: Impact of tenure documents alone

	Received tenure doc	Have some tenure doc	Threat of eviction	Tried to mortgage	Able to mortgage	Able to sell land
	(1)	(2)	(3)	(4)	(5)	(6)
Tenable	0.136***	0.120***	-0.0547**	0.00147	0.00283	-0.00658
	(0.0144)	(0.0168)	(0.0174)	(0.00270)	(0.00184)	(0.00528)
Untenable mean	0.09	0.17	0.34	0.00	0.00	0.02
Tenable mean	0.29	0.40	0.29	0.01	0.00	0.01
Slum FE	Yes	Yes	Yes	Yes	Yes	Yes
N	5824	5824	5850	5894	5894	5894

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table presents the ITT effects on variables related to receipt of tenure security document. The coefficients estimated are those in specification 4 estimated using OLS. The dependent variables are the household's report of whether they have received tenure documents, the household's report of having any tenure security document (those received under this program as well as from any other authority), their perceived threat of eviction from that land, whether they have tried to mortgage their tenure documents, their perceived ability to mortgage their tenure documents, their perceived ability to sell their land. The mean of all tenable and untenable households is also presented. The raw difference is different from the treatment effect coefficient due to the slum fixed effects. All regressions include slum fixed effects and a selected subset of pre-intervention covariates.

Table 12: Spillover effects of tenure documents

	Title	Eviction threat	House grant early	EL House quality
	(1)	(2)	(3)	(4)
Tenable * Slum propn untenable	0.112***	-0.127***	0.0476**	0.0429
	(0.0224)	(0.0251)	(0.0146)	(0.0560)
Tenable * Slum propn tenable	0.278***	-0.165***	0.0471***	0.137**
	(0.0197)	(0.0222)	(0.0129)	(0.0497)
Untenable * Slum propn tenable	0.105**	-0.167***	0.0111	0.0671
	(0.0373)	(0.0419)	(0.0243)	(0.0935)
Constant	0.0699***	0.424***	0.0421***	0.00734
	(0.0147)	(0.0166)	(0.00963)	(0.0370)
N	5824	5850	5915	5908
Ratio of spillover and main	38%	101.2%	24%	49%

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes.

8 Figures

Figure 1: Map of Odisha with cities in the sample

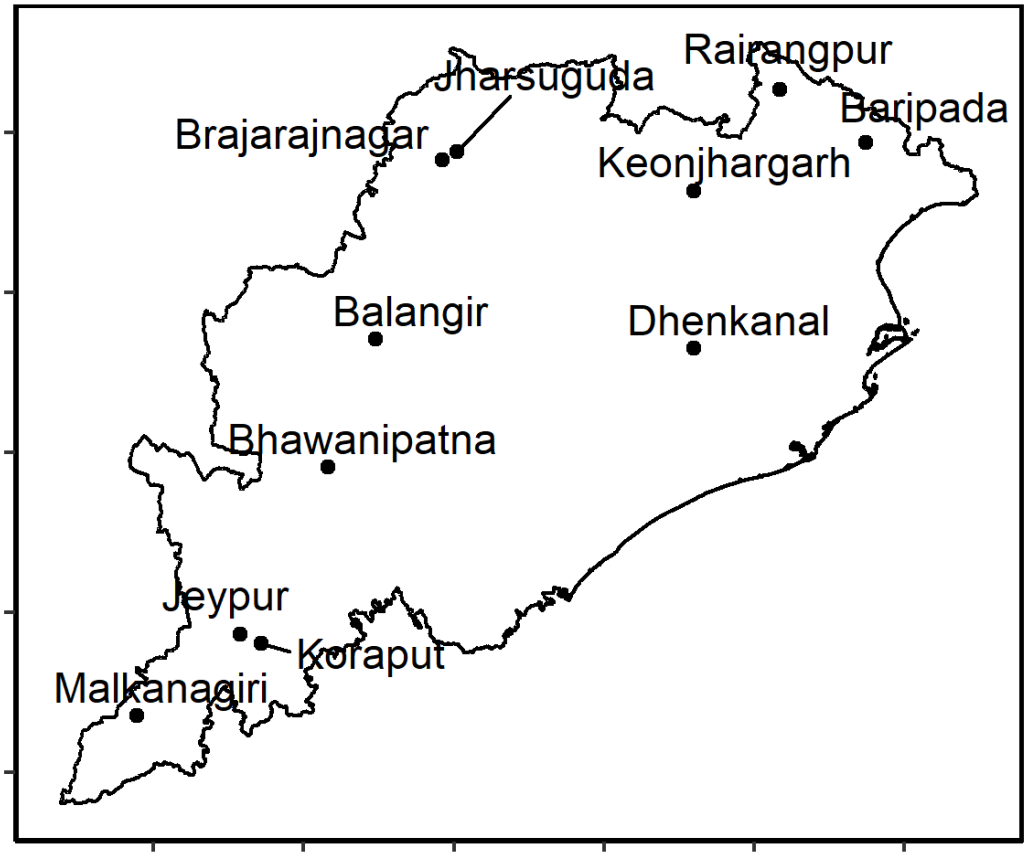
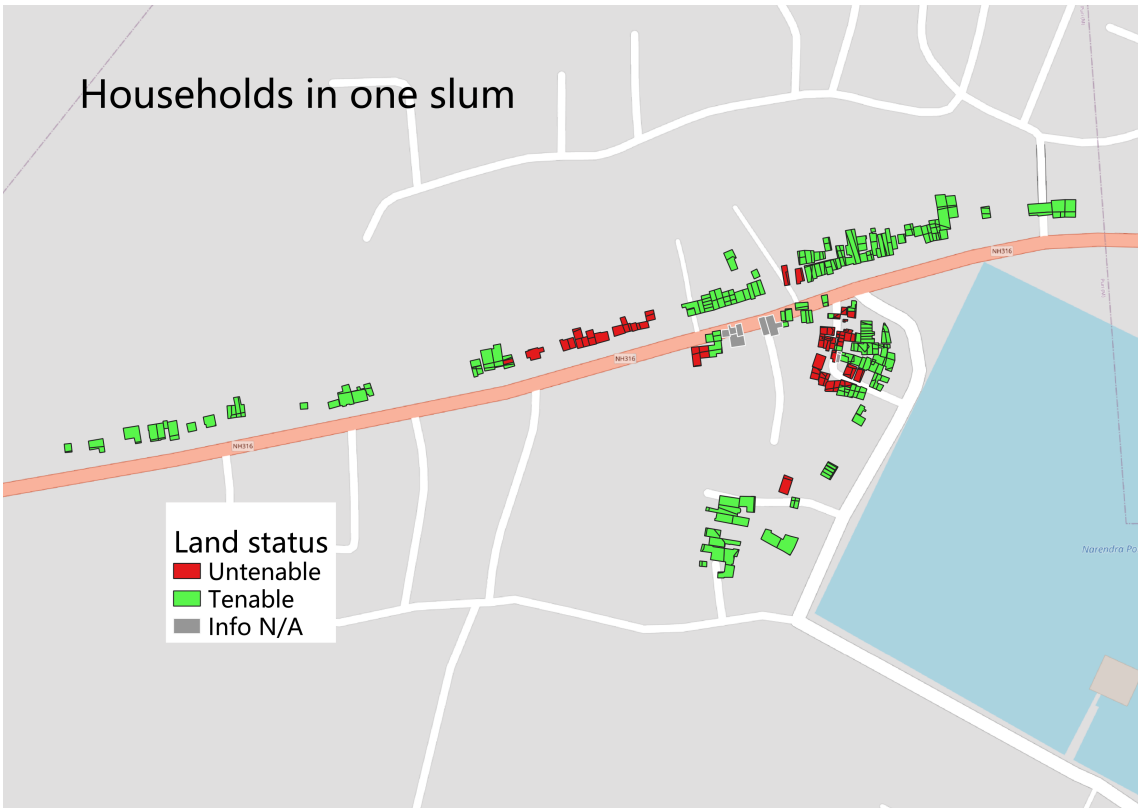


Figure 2: Distribution of tenable and untenable households in one slum



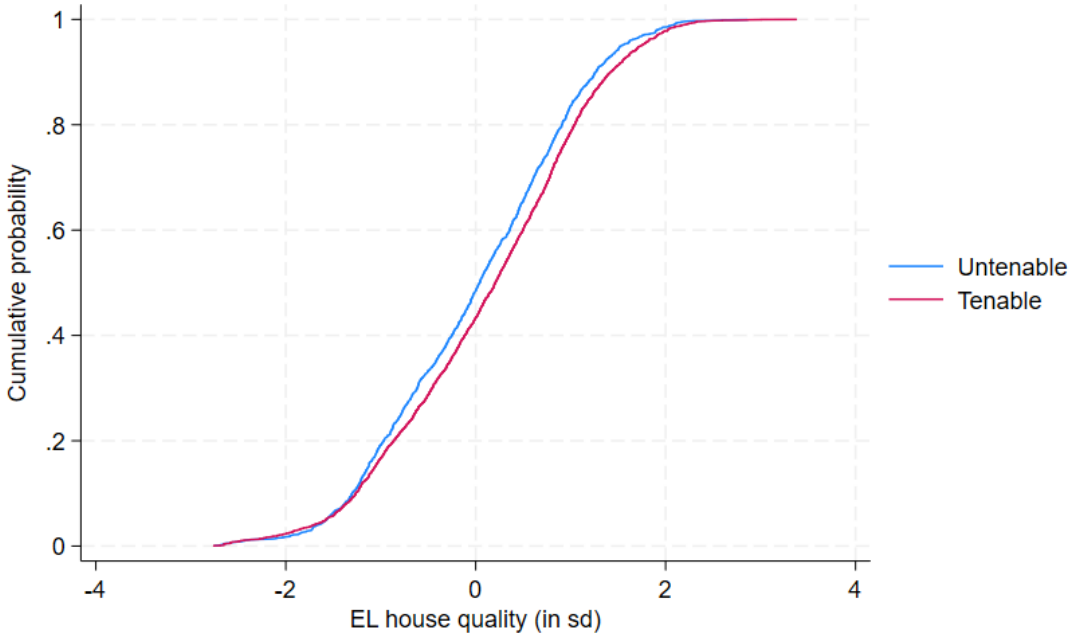


Figure 3: Distribution of house quality index measure in tenable and untenable households

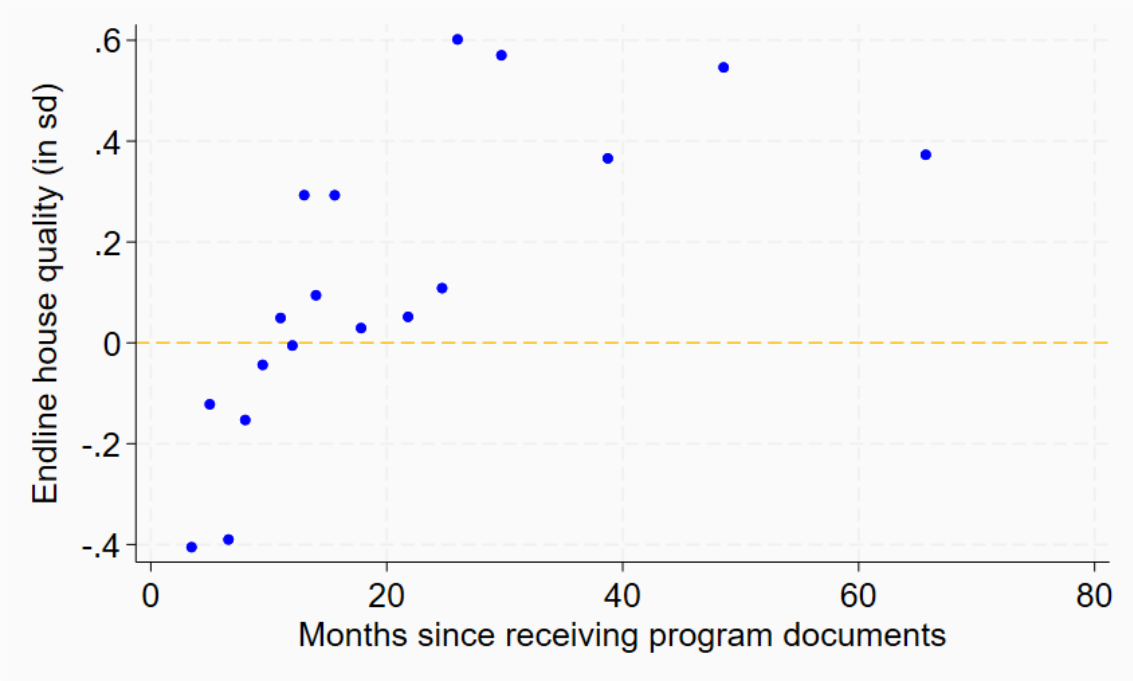


Figure 4: House quality as a function of time since receiving program documents

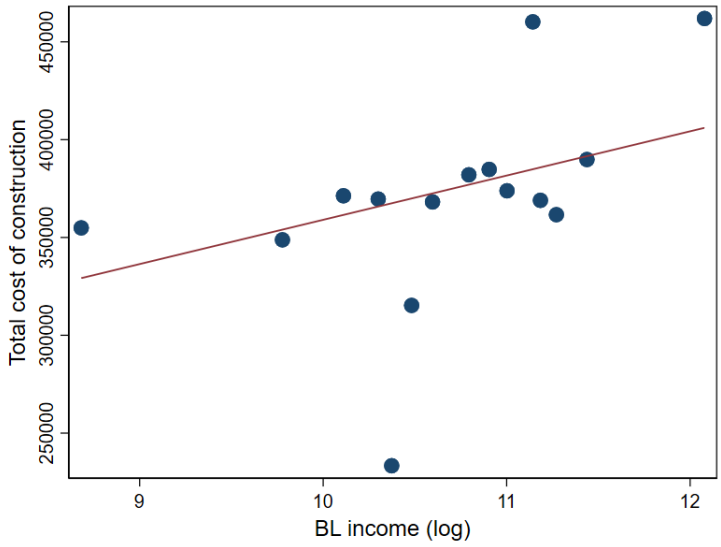


Figure 5: Construction cost as function of baseline income

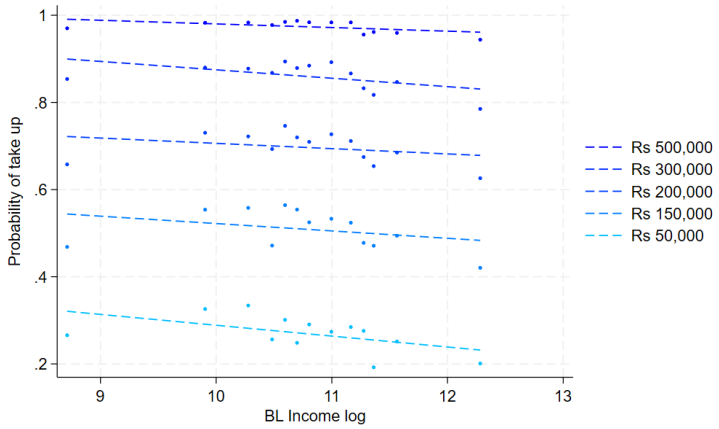
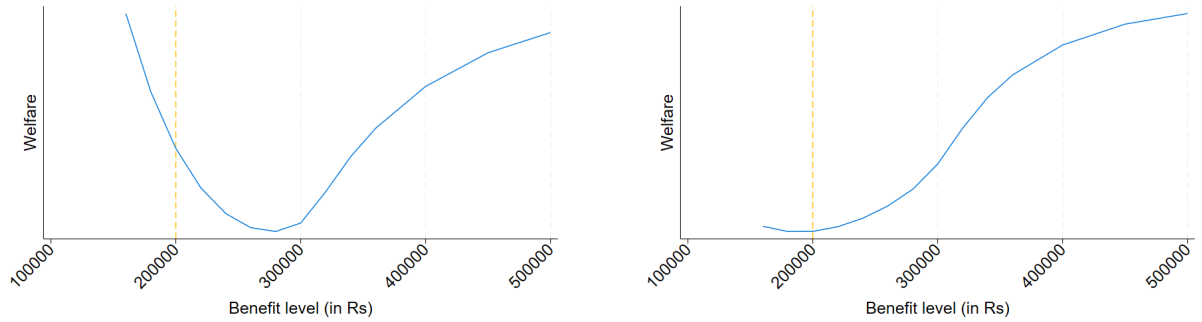


Figure 6: Take up probability across income groups by benefit levels



(a) Model predictions with uniform welfare weights (b) Model predictions with varying welfare weights

Figure 7: Estimated welfare transferred at different benefit levels

These figures present estimated aggregate welfare transferred at different benefit levels. In figure (a) all households are weighted equally while in figure (b) the households have a welfare weight inversely proportional to their baseline income quintile.

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9 Appendix

9.1 Appendix: Slum sample selection

There are 483 slums in all in the selected cities. I had reliable data for 333 slums from these cities and this forms the sampling frame for this survey. I designed the survey sample with two objectives: I wanted to estimate the treatment effects within a slum net of any general equilibrium effects and measure general equilibrium effects by comparing slums with fewer and more tenable households. However, there were imbalances in pre-intervention covariates across slums with fewer tenable households and slums with more tenable households.

I first defined a slum level propensity score to predict the share of tenable households in a slum using the baseline covariates. I regress the share of tenable households in a slum against slum level aggregates of pre-intervention covariates about house quality, household income, and demographics. I use the coefficients estimated to calculate the propensity score for each slum. Conditional on this propensity score, slums with more tenable households and slums with fewer tenable households have similar values of pre-intervention variables. Within each city I group slums according to propensity scores to create strata of 4 slums. I assume that conditional on being in the same strata, the share of the slums living on tenable lands is exogenous to other variables about the slum.

To be able to compare households within the same slum I need to select more slums which have an equal share of tenable and untenable households. To achieve this, I define a slum as being balanced if it has between 10% and 85% of households living on tenable lands. In each strata there are 4 slums. I include in the sample all strata which have 3 or 4 balanced slums. 97 slums are chosen this way. Among the remaining strata I choose 30 strata at random adding another 104 slums to the sample.

10 Appendix: Proofs of propositions

Proposition 1. *1. p_i decreases as current quality of house increases holding income fixed*

$$\frac{\partial p_i}{\partial h_i} < 0$$

2. p_i increases with benefit levels in the program

$$\frac{\partial p_i}{\partial b} > 0$$

3. *If $p_i > 0.5$, the partial derivative of p_i with respect to h_i decreases in magnitude with increase in the benefit level in the program b.*

$$\frac{\partial^2 p_i}{\partial b \partial h_i} > 0 \text{ if } p_i > 0.5$$

Proof. 1. As we saw above u_{yi} does not depend on h_i. From Assumption A2 u_{ni} is an increasing function of h_i conditional on I_i ($\frac{\partial u_{ni}}{\partial h_i} > 0$). That is households with a better quality house to start with have a higher utility in the absence of the program. (We can think of such households as starting with a larger endowment.)

$$\begin{aligned}\frac{\partial p_i}{\partial h_i} &= -\frac{p_i e^{u_{ni}}}{e^{u_{yi}} + e^{u_{ni}}} \frac{\partial u_{ni}}{\partial h_i} \\ &< 0\end{aligned}$$

2. If the benefit level in the program increases then u_{yi} increases while u_{ni} remains the same. Using this we have

$$\begin{aligned}\frac{\partial p_i}{\partial b} &= -p_i^2 e^{u_{ni} - u_{yi}} \times \left(-\frac{\partial u_{yi}}{\partial b}\right) \\ &> 0\end{aligned}$$

3.

$$\begin{aligned}
\frac{\partial^2 p_i}{\partial b \partial h_i} &= \frac{\partial \frac{\partial p_i}{\partial h_i}}{\partial b} \\
&= \frac{\partial - \frac{p_i e^{u_{ni}}}{e^{u_{yi}}+e^{u_{ni}}} \frac{\partial u_{ni}}{\partial h_i}}{\partial b} \\
&= -\frac{\partial u_{ni}}{\partial h_i} e^{u_{ni}} \left[\frac{1}{e^{u_{yi}}+e^{u_{ni}}} \frac{\partial p_i}{\partial b} - \frac{p_i}{(e^{u_{yi}}+e^{u_{ni}})^2} e^{u_{yi}} \frac{\partial u_{yi}}{\partial b} \right] \\
&= -\frac{\partial u_{ni}}{\partial h_i} e^{u_{ni}} \left[\frac{1}{e^{u_{yi}}+e^{u_{ni}}} \times p_i^2 e^{u_{ni}-u_{yi}} \times \frac{\partial u_{yi}}{\partial b} - \frac{p_i}{(e^{u_{yi}}+e^{u_{ni}})^2} e^{u_{yi}} \frac{\partial u_{yi}}{\partial b} \right] \\
&= -\frac{\partial u_{ni}}{\partial h_i} e^{u_{ni}} \left[p_i^3 e^{u_{ni}-2u_{yi}} \times \frac{\partial u_{yi}}{\partial b} - p_i^3 e^{-u_{yi}} \frac{\partial u_{yi}}{\partial b} \right] \\
&= -2 \frac{\partial u_{ni}}{\partial h_i} e^{u_{ni}} p_i^2 e^{-u_{yi}} \frac{\partial u_{yi}}{\partial b} \left[\frac{1}{2} - p_i \right] \\
&> 0 \text{ if } p_i > 1/2
\end{aligned}$$

■

Remark: Relationship between income and take up probability

Holding house quality fixed we see below that the partial derivative with respect to income can be positive or negative.

$$\begin{aligned}
\frac{\partial p_i}{\partial I_i} &= \frac{\partial \frac{1}{1+e^{(u_{ni}-u_{yi})}}}{\partial I_i} \\
&= -p_i^2 \times e^{(u_{ni}-u_{yi})} \times \left(\frac{\partial u_{ni}}{\partial I_i} - \frac{\partial u_{yi}}{\partial I_i} \right)
\end{aligned}$$

The sign of the total derivative with respect to income is also ambiguous. The stronger the correlation between income and housing, the more likely that the total derivative is negative and the take up is progressive.

$$\begin{aligned}
\frac{dp_i}{dI_i} &= \frac{\partial p_i}{\partial I_i} + \frac{\partial p_i}{\partial h_i} \frac{dh_i}{dI_i} \\
&= -p_i^2 \times e^{(u_{ni}-u_{yi})} \times \left(\frac{\partial u_{ni}}{\partial I_i} - \frac{\partial u_{yi}}{\partial I_i} \right) - \frac{p_i e^{u_{ni}}}{e^{u_{yi}}+e^{u_{ni}}} \frac{\partial u_{ni}}{\partial h_i} \frac{dh_i}{dI_i} \\
&= -p_i^2 \times e^{(u_{ni}-u_{yi})} \times \left(\frac{\partial u_{ni}}{\partial I_i} - \frac{\partial u_{yi}}{\partial I_i} + \frac{\partial u_{ni}}{\partial h_i} \frac{dh_i}{dI_i} \right)
\end{aligned}$$

Proposition 2. *The average welfare transferred per household to those with income I_i and house*

quality h_i is given by

$$W(h_i, I_i) = \log\left(\frac{1}{1-p_i}\right)$$

Proof. The total welfare transferred for individuals with income I_i and house quality h_i is given by

$$\begin{aligned}
V(u_y, u_n) = \int_{\mathbb{R}} \max(u_y + \lambda_y - u_n, 0) d\lambda_y \\
&= \int_{-(u_y-u_n)}^{\infty} (u_y - u_n + \lambda_y) \frac{e^{-\lambda_y/\beta}}{\beta(1+e^{-\lambda_y/\beta})^2} d\lambda_y \\
&= (u_y - u_n)\left(1 - \frac{1}{1+e^{(u_y-u_n)/\beta}}\right) + \int_{-(u_y-u_n)}^{\infty} \lambda_y \frac{e^{-\lambda_y/\beta}}{\beta(1+e^{-\lambda_y/\beta})^2} d\lambda_y \\
&= \beta \log\left(\frac{p_i}{1-p_i}\right) p_i + \int_{-(u_y-u_n)/\beta}^{\infty} \beta t \frac{e^{-t}}{(1+e^{-t})^2} dt \\
&= \beta \log\left(\frac{p_i}{1-p_i}\right) p_i + \beta \log\left(e^{-(u_y-u_n)/\beta} + 1\right) - \frac{(u_y - u_n)e^{-(u_y-u_n)/\beta}}{\beta(1+e^{-(u_y-u_n)/\beta})} \\
&= \beta \log\left(\frac{p_i}{1-p_i}\right) p_i + \beta \log 1/p_i - \beta \log\left(\frac{p_i}{1-p_i}\right)(1-p_i) \\
&= \beta \log\left(\frac{1}{1-p_i}\right)
\end{aligned}$$

■

11 Appendix Tables

Table 13: Balance table: Full sample frame

	Untenable		Tenable				
	n	mean	n	mean	Diff	Confidence interval	p-value
Occupied area (sqft)	16531	508.93	19317	509.58	-6.016	-15.898 - 3.865	0.23
Area per person (sqft)	12811	196.03	15581	198.36	-0.723	-6.987 - 5.540	0.82
Annual Income (winsorized)	14380	60618.89	17136	59895.58	789.965	-654.940 - 2,234.869	0.28
Income per capita (Rs)	12798	23164.28	15581	23168.80	537.454	-780.461 - 1,855.369	0.42
Permanent roof	14416	0.11	17122	0.10	0.005	-0.003 - 0.013	0.23
Brick wall	14422	0.60	17160	0.63	0.001	-0.012 - 0.013	0.92
Toilet in house	14421	0.42	17158	0.34	0.000	-0.012 - 0.012	0.97
Direct access to road	14421	0.75	17160	0.69	-0.006	-0.017 - 0.004	0.23
HH size	12823	3.24	15588	3.29	0.009	-0.037 - 0.055	0.70
Number of children	12816	0.91	15625	0.91	-0.028	-0.063 - 0.007	0.11
Average household age	12799	33.86	15585	33.63	0.015	-0.439 - 0.469	0.95
Proportion female	12822	0.51	15588	0.51	-0.008	-0.016 - -0.001	0.03*

Notes. The sample includes all households in the 11 cities that are a part of my sample. The first 4 columns present the mean and number of observations for individuals in tenable and untenable lands respectively. The last three columns present the coefficient of regressing the outcome on the tenability of the land with slum fixed effects, the 95% confidence interval, and the p-value. We can reject differences between the two groups larger than the confidence intervals.

Table 14: Balance table: PMAY earlier and later beneficiaries

	Late receipt		Early receipt				
	n	mean	n	mean	Diff	Confidence interval	p-value
Plot chars							
Occupied area (sqft)	447	430.91	447	401.27	-29.465	-64.963 - 6.033	0.10
Area per person (sqft)	447	167.69	447	159.08	-0.802	-18.930 - 17.327	0.93
Income							
Annual income (IHS)	444	8.06	447	8.17	0.003	-0.235 - 0.240	0.98
Annual Income (winsorized)	446	50275.89	446	54633.32	-850.975	-7,580.866 - 5,878.915	0.80
Income per capita (Rs)	447	19686.89	447	21817.67	952.273	-2,784.924 - 4,689.471	0.62
House quality							
Permanent roof	445	0.03	446	0.02	-0.018	-0.042 - 0.006	0.14
Brick wall	446	0.56	447	0.57	-0.056	-0.124 - 0.013	0.11
Toilet in house	446	0.30	447	0.23	-0.068	-0.126 - -0.010	0.02*
Direct access to road	446	0.67	447	0.56	-0.018	-0.073 - 0.037	0.52
Demographics							
HH size	447	3.10	447	3.18	-0.007	-0.216 - 0.203	0.95
Number of children	447	0.85	447	0.93	0.033	-0.127 - 0.193	0.68
Average household age	447	33.16	447	33.72	1.053	-1.156 - 3.262	0.35
Proportion female	447	0.53	447	0.53	-0.001	-0.038 - 0.035	0.94
Migration							
Years in slum	442	55.14	444	57.94	2.694	-1.718 - 7.106	0.23
Education							
Highest adult edu	421	6.26	428	6.09	-0.293	-1.013 - 0.426	0.42
Mean adult edu	419	4.62	427	4.35	-0.283	-0.867 - 0.301	0.34
Caste							
Advantaged caste	440	0.23	431	0.22	-0.028	-0.088 - 0.032	0.36
Scheduled caste	440	0.29	431	0.35	0.086	0.029 - 0.144	0.00**
Scheduled tribe	440	0.29	431	0.26	0.002	-0.058 - 0.062	0.94

Notes. The sample includes all sample households who have received the house construction grant. The first 4 columns present the mean and number of observations for individuals in tenable and untenable lands respectively. The last three columns present the coefficient of regressing the outcome on the tenability of the land with slum fixed effects, the 95% confidence interval, and the p-value. We can reject differences between the two groups larger than the confidence intervals.

Table 15: Attrition

	Untenable	Tenable	Diff	p-value
Survey complete	.83	0.79	-0.026	0.09
All dead	.015	0.01	-0.005	0.23
Merged with another	.015	0.02	-0.006	0.20
Refused	.073	0.09	0.016	0.14
House not found	.0094	0.03	0.002	0.77
Migrated	.061	0.06	0.019	0.04*

Notes. The first two columns are the proportion of tenable and untenable households attriting from the survey for that reason. The third column is the difference between tenable and untenable proportions estimated with a slum fixed effect. The fourth column gives us the p-value of the difference being different from 0.

Table 16: Impact on Housing quality

	Principal component		Willingness to pay		Satisfaction	
	(1) ITT	(2) LATE	(3) ITT	(4) LATE	(5) ITT	(6) LATE
Tenable	0.0586		0.0429		0.0346	
	(0.0323)		(0.0351)		(0.0366)	
Received PMAY		0.523		0.438		0.348
		(0.329)		(0.363)		(0.366)
Slum FE & BL controls	Yes	Yes	Yes	Yes	Yes	Yes
N	5908	5908	5908	5908	5908	5908

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table presents treatment effects of the house construction grant on different house quality measures. The dependent variable in the first two columns is the house quality index defined as the principal component of all individual measures. The next two columns use the predictors of willingness to pay rent for the house as the house quality index. The last two columns use the predictors of satisfaction with the house as the house quality index. The estimates are coefficients from specification 4. All regressions include slum fixed effects and baseline controls.

Table 17: Impact on housing quality adjusted for construction phase

	Principal component		Willingness to pay		Satisfaction	
	(1) ITT	(2) IV	(3) ITT	(4) IV	(5) ITT	(6) IV
Tenable	0.0672*		0.0502		0.0415	
	(0.0336)		(0.0375)		(0.0374)	
Received PMAY		0.990*		0.739		0.611
		(0.500)		(0.550)		(0.549)
Slum FE & BL controls	Yes	Yes	Yes	Yes	Yes	Yes
N	5464	5464	5464	5464	5464	5464

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table presents treatment effects of the house construction grant on different house quality measures. The dependent variable in the first two columns is the house quality index defined as the principal component of all individual measures. The next two columns use the predictors of willingness to pay rent for the house as the house quality index. The last two columns use the predictors of satisfaction with the house as the house quality index. The estimates are coefficients from specification 4. Observations are re-weighted to estimate the impact net of the effect of transitory phase during construction. All regressions include slum fixed effects and baseline controls.

Table 18: Impact on components of house quality adjusted for construction phase

	Untenable	Tenable	Diff	Confidence interval	p-value	IV
Targeted measures						
Roof						
Concrete	0.14	0.28	0.065	0.033 - 0.097	0.00***	0.973***
Tiled	0.30	0.39	0.044	0.007 - 0.080	0.02*	0.659*
Good asbestos	0.71	0.73	-0.008	-0.043 - 0.028	0.67	-0.114
Bad asbestos	0.97	0.96	0.007	-0.008 - 0.021	0.36	0.098
Non-targeted measures						
Painted walls	0.56	0.57	0.015	-0.022 - 0.053	0.42	0.231
Wall						
Brick	0.66	0.71	0.027	-0.009 - 0.062	0.14	0.402
Mud	0.87	0.88	0.034	0.007 - 0.060	0.01*	0.503*
Metal/asbestos	0.97	0.97	0.013	-0.001 - 0.027	0.07	0.193
Floor						
Tiles	0.05	0.08	0.009	-0.011 - 0.030	0.37	0.140
Cement	0.72	0.76	0.009	-0.023 - 0.041	0.59	0.135
Toilet						
In-house w water	0.15	0.18	0.000	-0.030 - 0.030	1.00	0.001
In house	0.33	0.33	0.000	-0.035 - 0.036	0.99	0.002
Exclusive	0.52	0.57	0.023	-0.012 - 0.058	0.21	0.340
Shared	0.57	0.60	0.028	-0.007 - 0.062	0.12	0.416
Other features						
Door with latch	0.86	0.87	0.014	-0.012 - 0.040	0.30	0.210
Concealed wires	0.39	0.46	0.023	-0.015 - 0.061	0.24	0.342
Num windows	1.37	1.59	0.025	-0.095 - 0.144	0.69	0.366
Num rooms	2.75	2.78	-0.041	-0.149 - 0.067	0.46	-0.612
Theft threat	0.18	0.17	-0.006	-0.037 - 0.024	0.68	-0.096
Problems during rain						
Roof not leaking	0.27	0.31	0.026	-0.011 - 0.063	0.17	0.386
Door not leaking	0.52	0.50	0.008	-0.032 - 0.048	0.70	0.120
Wall not leaking	0.52	0.50	-0.007	-0.047 - 0.033	0.72	-0.110
No water logging	0.85	0.84	0.026	-0.003 - 0.055	0.07	0.389

Notes. The first two columns are the raw means of households living on untenable and tenable lands respectively. The third column is the ITT estimate from specification 4 and the fourth and fifth columns are the corresponding 95% CI and p-value. The last column is the LATE of the house construction grant. For variables about roof, wall, and floor, the values are cumulative. The row title should be read as "Does the house have a tiled roof or better material roof?". For the problems faced by the households during rains, the values are the proportion of households reporting facing this problem. These questions have been inverted so that for all variables a higher value can be interpreted as a better quality house. Households who received the grant documents less than a year before the survey are dropped and the households who received the grant documents more than year ago have a weight of 2 in these regressions.

Table 19: Impact on outcomes indices

(a) Income

	Total income	Business income	Wage income	Any business
	(1)	(2)	(3)	(4)
Tenable	143.4	67.50	59.05	0.00806
	(161.9)	(74.93)	(132.4)	(0.0203)
Control mean	3257.37	570.83	2164.78	0.32
Slum FE	Yes	Yes	Yes	Yes
N	4809	4825	4825	4820

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Health

	GAD-7	IMR	Fever	Diarrhoea	Unsatisifed with life	Unsatisfied with sleep
	(1)	(2)	(3)	(4)	(5)	(6)
Tenable	0.332	-0.0566	0.00939	0.00541	0.0188	-0.0193
	(0.249)	(0.0333)	(0.0140)	(0.0145)	(0.0598)	(0.0573)
Control mean	6.60	0.23	0.24	0.08	1.04	0.70
Slum FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4791	1337	4825	3049	4812	4812

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(c) Assets

	Asset value	TV	Fridge	Bed	Smartphone	Chair
	(1)	(2)	(3)	(4)	(5)	(6)
Tenable	-1002.9	-0.0285	-0.0195	-0.0735	-0.00839	-0.169*
	(926.7)	(0.0220)	(0.0207)	(0.0406)	(0.0432)	(0.0832)
Control mean	36633.37	0.70	0.34	1.15	1.23	2.20
Slum FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4813	4821	4816	4821	4818	4819

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes.

Table 20: Impact on outcomes indices

(a) Consumption

	Expenditure per capita	Food exp pc	Consumables exp pc	Exp towards repaying loans
	(1)	(2)	(3)	(4)
Tenable	88.95	42.32	9.617	37.87
	(167.5)	(36.65)	(23.90)	(42.56)
Slum FE	Yes	Yes	Yes	Yes
N	4825	4825	4825	4825

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Loans

	Total loans per capita	Source of loans			Savings	Net assets
	(1)	(2) Banks	(3) Chit fund	(4) Moneylender	(5)	(6)
Tenable	1693.0	1293.3	388.4	5.993	-4866.8	-6401.2
	(1292.8)	(1047.8)	(387.4)	(553.9)	(4241.9)	(4462.5)
Slum FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4825	4825	4825	4825	4825	4825

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes.

Table 21: Impact of tenure documents alone

Tenure documents	Grant received	House quality improvement
No	No	0.390
Yes	No	0.454
Yes	Yes	1.171
No*	Yes	1.109

Notes. This table pools all the households living on tenable and untenable households together but classifies them based on whether they report having received some tenure documents and having received the house construction grant. Some households reported not having the tenure documents but receiving the house construction grant. They may have forgotten about the tenure document or the municipal authorities may not have given them the document. The third column is the mean change in house quality from baseline to endline for households in that category. The change is measured in a common house quality index using only the variables available in both the baseline and the endline.