John F. Kennedy School of Government
Harvard University
Faculty Research Working Papers Series

Can Good Projects Succeed in Bad Communities? Collective Action in the Himalayas

Asim Ijaz Khwaja

March 2001

RWP01-043

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Abstract

This paper examines, theoretically and empirically, the determinants of collective success in the maintenance of infrastructure projects. The empirical analysis employs primary data collected by the author on 132 community-maintained infrastructure projects in Northern Pakistan. Determinants are grouped into community-specific and project-specific factors, the latter identified using community fixed effects. The analysis shows that community-specific factors are important: Socially heterogeneous communities have poorly maintained projects and community inequality has a U-shaped relationship with maintenance. Project leaders are associated with higher maintenance, with attributes of hereditary leader households used as instruments for leader presence. However, the results suggest that the effects of project-specific factors are even larger. Specifically, complex projects are poorly maintained and inequality in project returns has a U-shaped relationship with maintenance. Increased community participation in project decisions has a positive effect on maintenance for non-technical decisions but a negative effect for technical decisions. Projects initiated by non-governmental organizations are better maintained than local government projects, as are projects made as extensions of old projects rather than anew. The findings are consistent with the theory and suggest that adverse community-specific factors, such as a lack of social capital, can be more than compensated for by better project design.

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[*] John F Kennedy School, Harvard University, Cambridge MA 02138, USA. Email: asim_ijaz_khwaja@harvard.edu. I would like to thank Alberto Alesina, Abhijit Banerjee, Jishnu Das, Esther Duflo, Oliver Hart, Sehr Jalal, Michael Kremer, Atif Mian, Ted Miguel, Carolina Sanchez, Jeffrey Williamson and seminar participants at Harvard University and the NEUDC conference at Cornell University for comments. I gratefully acknowledge financial support from the Social Science Research Council and the MacArthur Foundation and am indebted to the Aga Khan Rural Support Program Pakistan staff for providing support and company during the fieldwork. All remaining errors are my own.

1. Introduction

Virtually every development intervention, whether initiated by an external organization or by a community itself, has to motivate participants to cooperate and coordinate for mutual benefit. Collective action has therefore received a lot of attention, especially concerning why some communities are able to cooperate while others fail, and how such success may depend on the nature of the collective task. The recent emphasis on social capital suggests that community-specific features such as group size, inequality, and heterogeneity are paramount in determining collective success (Putnam 1993, 1995; Robert 1993; Alesina et al., 1999). This is in contrast to an older literature that emphasizes appropriate project design as a means of improving project sustainability (Hirschman, 1967; Stewart 1978; Betz et al., 1984) and a more recent literature that focuses on improving institutions and management structures (Ostrom, 1990; Uphoff, 1996; Lam, 1998). However, a comparative analysis of community and project-specific factors remains missing: What is the relative importance of project-design factors compared to community-specific factors in determining collective success? Specifically, is it possible to design projects that are likely to be successfully maintained even in communities with adverse attributes such as low social capital?

This paper addresses these questions by estimating the relative impact of community and project-specific factors on the upkeep of community-maintained projects. Project maintenance is, as detailed below, both a good measure of collective success and an important issue in itself; the lack of project sustainability is a serious concern in developing countries. The empirical analysis employs primary data collected by the author on 132 infrastructure projects in 99 communities in Northern Pakistan. The contributions of this paper are best evaluated in comparison to existing work that has consisted of anecdotal evidence and case studies and only recently attempted econometric analyses of collective action determinants (Wade, 1987; Lam, 1998; Dayton-Johnson, 1999; Agarwal, 1999; Miguel, 1999). These econometric studies, limited by surveys that examine a single type of task and sample only one task from each community, are unable to identify the effect of project-specific factors. This paper addresses both limitations. The data was collected to allow for variation in the type of collective task (simple irrigation channels to complex electricity units) and variation in collective performance outcomes within communities (by surveying two projects in a community), making it possible to identify and contrast the effects of project and community-specific factors.

Figure 1 presents further motivation and a first look at the relative impact of the two groups of factors. The figure only considers those communities in which two projects were surveyed (33). Each project is ranked according to project maintenance, which is the main measure of collective success constructed using the primary data. Figure 1 plots the rank of the first project in a community against the rank of the second project. If community-specific factors are paramount, each project in a “good” community will be maintained better than all projects in a "bad" community and all points should lie along the 45^0 diagonal. Figure 1 shows this is not the case: While a few communities do lie on or close to the diagonal, most do not.[1] The data also reveals that more than half the variation in project maintenance comes from within, rather than between communities.[2] This suggests that, while community-specific factors do matter, they can at best only account for half the variation in collective performance. This paper elaborates on the suggestive evidence presented in Figure 1 through a theoretical and empirical analysis of the effects of community and project-specific factors on maintenance.

The theory in this paper illustrates how project maintenance varies with project and community-specific factors. The model developed is a standard non-cooperative game theory model (Moral Hazard in Teams; Holmstrom, 1982). It focuses on project-specific attributes and complements existing models that emphasize community-specific attributes such as size, ethnic, and socioeconomic differences (Olson, 1965; Baland and Platteau, 1998; Bardhan, 1999; Alesina and La Ferrara, 1999; Agarwal, 1999).

Project maintenance in the model is determined by the total capital and labor contribution made by community households. Each household chooses its contribution based on its net project return. Project return both depends on the household's observed share in the project (i.e. its share of land in the command area of an irrigation project) and on its influence in the community. Households contribute their own labor and/or non-household labor. They face convex costs for their own labor, and hire non-household labor at a fixed wage. Capital (i.e. cash) contributions are verifiable and therefore contractible, but can be appropriated. Thus, capital contributions are an issue, not because of credit constraints, but due to greater appropriation risks inherent in such (non-labor) contributions. Capital and labor are complementary inputs in project maintenance. Community participation in project decisions is modeled simultaneously as an investment and as a means of exercising influence in the project. The model generates several testable claims.

First, inequality in realized project returns has a U-shaped relationship with maintenance. Initial increases in inequality lower maintenance, as the household with greater share of benefits does not contribute enough to compensate for the fall in contribution from the household with the lower benefit share. As inequality increases further, the gaining household can afford to hire non-household labor, and this more than compensates for the losing household. *Second*, complex projects – those in which the community has had no

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[1] The patterns in Figure 1 could also arise if there is significant measurement error in project maintenance. Subsequent empirical results in this paper suggest that this is unlikely to be the case. Moreover, as detailed in the data description section, care is taken to ensure that the maintenance measure constructed is reliable and accurate.

[2] The standard deviation of project maintenance within communities is 19.18 compared to the standard deviation across communities of 16.24.

prior experience and require greater capital than labor contributions – have lower maintenance, since household contributions are less productive due to the greater appropriation such projects face. *Third*, project leaders may reduce or facilitate appropriation and thus have an ambiguous effect on maintenance. The leadership effect is larger for more complex projects. *Fourth*, community participation in non-technical project decisions, which may have been made in the past, is beneficial for maintenance today. However, participation is detrimental in technical decisions. Since non-technical decisions require greater local knowledge, community participation in such decisions increases the productivity of household maintenance contributions ever afterwards and hence raises overall contributions. In contrast, technical decisions require skills better provided by the external organization. Community participation in such decisions crowds out the external organization's influence and therefore reduces the productivity of maintenance contributions and lowers maintenance.

The empirical findings support the theoretical claims and offer a broader examination of the community and project-specific determinants of maintenance. The analysis focuses on the maintenance of externally supported infrastructure projects (irrigation channels, roads, protective walls etc.) for two reasons. *First*, the problem is important in itself. The level of infrastructure is abysmally low in developing nations; Chad has an estimated $30 per-capita infrastructure stock as compared to $9000 per capita in Norway (World Bank, 1994). A contributing factor is poor maintenance, as most investments rarely last their expected lifetimes. Estimates by multilateral development agencies show that, in the last decade alone, $12 billion in regular maintenance expenditure could have prevented an actual $45 billion spent on road reconstruction in Africa. *Second*, project maintenance provides a good instance of the collective action problem in general. Measuring collective success is non-trivial – restricting to infrastructure projects simplifies matters as project condition can be measured precisely and compared across projects. The focus on externally supported projects allows for variation in the nature of the external organizations, and provides accurate project cost and characteristics information. Finally, since the external organizations only support project construction, maintenance is the community's responsibility, and provides a more accurate measure of its collective abilities than project completion or construction quality. The maintenance measure is constructed on a percentage scale with a score of 100 assigned if the project is in the same condition as when it was built.

The empirically important community-specific factors are social heterogeneity, community inequality, and leadership. Social heterogeneity is determined by heterogeneity in clan, religious, and political groups in the community, while community inequality is indexed by inequality in land holdings. *Heterogeneity* adversely effects maintenance. *Land inequality* has a U-shaped effect on maintenance, and the presence of a *project leader* is associated with higher maintenance. Leader presence is instrumented with attributes of hereditary-leader households such as whether the household has a healthy male member between 25 to 50 years old. The results are robust to an extensive set of community and project-specific controls and the estimated effects are economically significant. As an example, a increase from the 1st to 3rd quartile in social heterogeneity is associated with a 9.6 percentage points fall in maintenance.

Project-specific factors also have significant effects. *Complex projects*, as indexed by higher capital and skilled labor requirements and lower experience, have worse maintenance. Projects made as extensions of existing community projects (*continuation projects*) are better maintained than new projects. Similarly, projects initiated by *non-governmental organizations* (NGOs) have higher maintenance than those initiated by the local government. This result is particularly interesting since neither organization provides any help in maintenance; project upkeep is only determined by community effort. In contrast to the existing literature, *community participation* is not found to be an unqualified good: While community participation in *non-technical decisions* is beneficial, it is detrimental in *technical decisions*. Finally, *inequality* in the observed distribution of project returns has U-shaped relationship with maintenance. Compared to the U-shaped effect for community inequality, the positive part of the U-shaped effect is larger for this project-specific inequality measure. The magnitudes of the project-specific effects are large. For example, an increase from the 1st to 3rd quartile in project complexity is associated with 25.5 percentage points lower maintenance, and continuation projects have 41.9 percentage points higher maintenance than new projects. All the results are robust to project controls and identified using community and project-type fixed effects.

The positive interaction between leadership and project complexity in the model is also supported in the data; the leadership effect is 38 percentage points higher for complex projects relative to simple projects. In addition, the difference between the maintenance of NGO and local government projects is larger for complex compared to simple, and for new compared to continuation projects.

The rest of this paper is structured as follows: The setting in the Himalayas is described in Section 2. The theory is presented in Section 3, and the data and empirical strategy detailed in section 4. Section 5 then presents the empirical findings and Section 6 concludes.

2. Setting

Baltistan is a sparsely settled Himalayan region in Northern Pakistan (Figure 2). Villages range from small and remote pastoral settlements of 10 households (with 6-8 members per household), to larger ones with 200 or more households, and from altitudes of 7,000 to 12,000 feet above sea level. Weather conditions are extremely harsh, with temperatures varying from -20^0 Celsius in the winter to 40^0 Celsius in the summer. Floods, landslides, and avalanches occur frequently, and with very damaging consequences.

The region has one of the lowest standards of living in Pakistan, with annual per-capita income estimated at $216 (Parvez, 1998). Economic inequality is high, though lower than in the rest of the country – Parvez (1998) estimates a total income Gini coefficient of 0.35 in Baltistan as compared to 0.41 in Pakistan. Land reforms in the 1970s transferred ownership rights from the local rulers to the community members (Dani, 1989). As a result, 79% of all farmers own their land and only 2.2% are tenants (1981 Census). Land markets are virtually non-existent and land distribution, frozen since the reforms, is based on the history of settlement, household structure, and inheritance (MacDonald, 1994).

The main lines of social differentiation are along clans and religio-political groups. Clans are generally unique to the community and trace a common ancestor. The overwhelming majority of the population is Muslim, though there are significant tensions between the Shia, Nur Bakhshi, Sunni, and Ismaili sects. There are two main political parties, the *Tehrik* and the *Peoples Party*. Party loyalties are based on religious and familial associations rather than party platforms, resulting in little movement across party lines. While conflicts based on such clan and sectarian differences do arise, they seldom turn violent.

The community management system is similar to the *panchayat* structure prevalent in south Asia; a group of elders is responsible for community affairs and is headed by a hereditary leader, the *trampa*. “The position of *trampa* – no longer formally recognized by the government but practically recognized by villagers, usually passes, upon death, with its attendant obligations, duties and privileges from father to eldest son” (MacDonald, 1994).

Two major constraints to development in the region are scarcity of irrigation water and poor road access. With low annual precipitation at 150-200mm (Whiteman, 1985), the main sources of water for the predominantly agriculture based economy are glacial melt and rivers. The regional capital, Skardu, offers the only road connection to the rest of the country, but this link is often disrupted for weeks due to frequent landslides. Most villages remain unconnected to Skardu and the rocky and steep terrain makes for very slow movement even on the few metalled roads; a 40-mile journey can take 4 hours in a jeep.

The level of basic services and infrastructure is particularly low, with the harsh climatic conditions leading to rapid project degradation unless regular maintenance work is carried out. It is therefore common to see projects lying damaged and poorly maintained even within the first year of construction.

The majority of infrastructural projects in Baltistan are irrigation and road projects, with two main funding organizations – the local government’s Local Bodies and Rural Development (LB&RD) section and an NGO, the Aga Khan Rural Support Program (AKRSP).[3] Both construct similar projects and only provide technical and financial support. Each sends out its engineering team to survey the community, select the site and design the project. The community then constructs the project under the engineering team's supervision.

However, there are significant differences in their approaches: AKRSP emphasizes that local needs are collectively identified and, as supported in the data, is able to elicit greater community participation at each stage of the project. A prerequisite for the AKRSP's involvement is to setup a village organization (VO) that has majority community representation and officials elected by the community. All project decisions, from project identification to usage rules and fund disbursements, are then carried out through the VO. The LB&RD has no such emphasis – it allocates funds to the community (usually based on political considerations) and disburses them through the LB&RD representative. A union council member appoints the representative. Union council members are elected through voting at the union level; a union consists of several villages. Thus, while both agencies work through elected bodies, the NGO process is at a more localized level and relies on a group of community members rather than a single community representative. Donor funding implies that the NGO is required to maintain transparent accounts. The local government, on the other hand, has no clearly defined system of accountability.

3. Model

The model focuses on the problem of project maintenance and on a specific set of factors, the community's return distribution and participation in the project, project leadership, and complexity. Since the theory is concerned with examining the marginal effect of these determinants, it abstracts away from the role of norms, reputation and repetition in sustaining cooperation. That is not to assert that these issues are not important, as they undoubtedly are, but to focus on the variables of interest. Moreover, rather than solve for the optimal mechanism, it illustrates how maintenance is affected as model parameters vary, given that households non-cooperatively choose their maintenance contributions.

Environment:

The community consists of N households. Each household *i*, contributes capital[4] and labor towards project maintenance. The labor contribution can be direct or indirect. Direct labor is the household's own labor and is limited by household size. Indirect labor is supplied using workers hired by the household from the labor market under a wage contract. There are no supply constraints in the labor market.

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[3] The AKRSP has been working in the region since 1984 and is involved with other development interventions such as agricultural support services, micro-credit and enterprise development. The majority of the NGOs resources are spent on helping construct infrastructure projects.

[4] Capital is broadly conceived as including expenditure on spare parts, fuel and outside technical labor.

Household i contributes capital k_i, direct labor l_i, and indirect labor m_i at costs of $C_k(k_i)$, $C_l(l_i)$, and $C_m(m_i)$ respectively; the cost functions are identical for all households. Capital contributions are verifiable. Verifiability in this context means that the capital input is contractible and contracting is costless. Labor however, can only be verified at a cost. While $C_k(k_i)$ and $C_m(m_i)$ are linear functions, $C_l(l_i)$ is strongly convex i.e. $C_l'''(l_i) > 0$ in addition to $C_l''(l_i) > 0$. This assumption is based on strongly decreasing returns to household labor in a given task. In contrast, the linearity of $C_m(m_i)$ captures the fact that outside labor can be hired at the constant market wage. Specifically $C_m(m_i)= M_0 + wm_i$ where M_0 represents any fixed monitoring (verification) costs and w, the market wage and any marginal monitoring costs. The cost of capital is $C_k(k_i)= rk_i$. Project maintenance and, without loss of generality, total project benefit, is given by the concave function $B = f(\sum_{i=1}^{N} k_i, \sum_{i=1}^{N}[l_i + m_i])$. Indirect and direct labor are perfect substitutes, and capital is a complement to both, with the degree of complementarity varying across project types.

Household i's realized project benefit is $B_i = \frac{r_i}{(r_1 + .. + r_N)} B(.)$ where r_i captures the household's absolute ownership of project returns. This is an extension of the ownership concept in the property rights literature: ownership is not only considered over physical assets, but also over intangible ones such as the right to make decisions affecting the project. A household's "r_i" is determined not only by its physical share in the project – for example, the land it owns in the command area of an irrigation project – but also by factors that affect its influence in the community, such as its socio-economic status. Having influence allows the household to redirect community contributions in the project to generate higher benefits for itself i.e. spend more on repairs to sections of the irrigation channel next to its land.

Field observations indicate that households are reluctant to contribute capital to the project as, unlike their own labor which naturally contains a monitoring aspect, it is difficult to ensure that one's capital contributions are spent on project maintenance – a fraction of such contributions can and are appropriated.[5] This is introduced in the model with degree of appropriation given by $\alpha \in [0,1]$; for a given capital contribution k_i exerted by a household, only $(1-\alpha)k_i$ is actually spent on project maintenance. Moreover, α is an increasing function of the relative (to labor) capital requirements of the project and a decreasing function of project experience, and leadership quality. It is likely that the greater the capital versus labor requirement in the project, the easier it is to appropriate, since the relatively lower labor input also implies less automatic

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[5] The assumption made is that contributions are appropriated by external parties. While community households can in principle appropriate, allowing this would reduce the tractability of the model and not significantly add to or alter its predictions. Additionally, an alternate interpretation of the capital loss that abstracts from such issues is misuse rather than appropriation; a community is likely to misapply and waste capital rather than the simpler labor inputs.

monitoring. Community experience provides a benchmark for required capital expenditure, and therefore reduces appropriation. “Good” quality project leaders ensure that appropriation is less likely by providing both additional monitoring, and project-specific knowledge. However, (bad) leaders may also increase appropriation if the leader colludes with or is the appropriating party. Leadership affects α through its interaction with the other determinants. It therefore, has no effect in a project that does not face any appropriation risks.

The timing of the stage game is that households contribute inputs at time 0, and at time 1 project maintenance/benefit is realized. In order to abstract away from repetition and reputation concerns, there is only a one shot contribution and realization of benefits i.e. households only live for one time period.

Model Solution:

The model solves for the Nash equilibrium as each household maximizes its net project return. The analysis can be simplified by recognizing that the verifiability of capital allows a reduction of the household decision to only choosing direct and indirect labor, given the communities' overall capital choice.[6] In addition, a tractable way of introducing and varying capital and labor complementarity, is through a Leontief production technology i.e. $B = f(\min\left\{\frac{1}{\gamma}\sum_{i=1}^{N} k_i, \sum_{i=1}^{N}[l_i + m_i]\right\})$; projects requiring greater capital have a higher γ. The community's overall capital choice is now uniquely determined by aggregating individual labor choices.

In order to focus on the capital appropriation effect as project capital requirements vary, price effects arising due to the different capital requirements are ignored, by allowing the price of capital to vary inversely with γ. Project benefit is now simply $B = f((1-\alpha)\sum_{i=1}^{N}[l_i + m_i])$. The productivity of labor is reduced by the capital input appropriation factor due to the complementarity between capital and labor. Households choose direct and indirect labor to maximize their net return from the project, as given in equation 1:[7]

$$(1) \qquad l_i^*, m_i^* \in \arg\max_{l_i, m_i}\left\{\frac{r_i}{(r_1 + .. + r_N)} \cdot f\left((1-\alpha)\cdot\sum_{i=1}^{N}[l_i + m_i]\right) - C_l(l_i) - M_0 - w\cdot m_i\right\}$$
$$s.t.\ l_i \geq 0, m_i \geq 0$$

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[6] Verifiability implies that the distribution of capital contributions has no effect on household labor choice provided the household continues to participate in the project.

[7] The complete net return expression also includes the household's capital input costs but, given the assumptions above, this cost does not alter the household's optimal labor choice or comparative statics as long as all the households continue to participate in the project. It is therefore ignored in the analysis.

Definition: A "standard" community project is one where:

(i) $l^*_i > 0$ and $m^*_i = 0 \ \forall\ i$ if $r_i = r_j \ \forall\ i,j$

(ii) $m^*_i > 0$ if $r_i >> r_j \ \forall\ j$

The interpretation is straightforward: A standard project is one in which no household prefers to hire any outside labor if it commands a small (equal) share of project return. However, as a household's share increases, it eventually becomes too expensive for this high share household to contribute its own labor and it prefers to also hire outside labor. Since outside labor is relatively expensive (monitoring and verification costs), households only resort to outside labor if they have to contribute a significant fraction of total project labor i.e. if they command a large portion of project returns. In terms of the above definition, most projects in Baltistan are likely to be "standard" community projects.

Testable claims generated by the model are presented below. Proofs are in the Theory Appendix.

Claim 1: *For a standard community project, maintenance initially worsens as project return inequality increases from perfect equality. However, the trend is reversed at higher inequality levels, and further increases in inequality improve maintenance.*

Intuition: Starting from perfect equality, all households only contribute direct labor. Initial increases in inequality lower overall maintenance; the household with increased project return does not raise its direct labor input as much as the households with the decreased project return lower their direct labor inputs, since the former faces relatively lower net marginal returns to direct labor. Eventually, as the high share household's net return increases enough, it prefers to employ indirect labor. In a sense, the project has been partially privatized. Further increases in its return now raise overall maintenance, as it is able to employ greater amounts of indirect labor at a constant wage and decreasing average fixed costs, and is more than able to compensate for the low return households' fall in direct labor.

Claim 2: *More complex projects – those that require greater capital inputs and lack prior community experience – have lower maintenance, regardless of the community's characteristics. Projects that lack good quality leaders also have lower maintenance, although there is an ambiguous effect of leader presence. The leader effects are larger for more complex projects.*

Intuition: The claim follows from the setting above: Complex projects face greater levels of appropriation, both because they require greater capital relative to labor inputs, and because the community lacks prior experience as to what these capital costs should be. This greater appropriation lowers the productivity of labor and hence, maintenance of the project. Leaders matter in so far as they affect such appropriation by external parties. Good quality leaders reduce appropriation but leaders in general may increase it. Given that this is the only role that leaders play in the model, the leadership effect is only relevant if the project runs the risk of appropriation i.e. the effect increases with project complexity.

Introducing community participation:

There is a lot of anecdotal, and some empirical evidence, that suggests community participation in decisions taken at the time the project was made, ensure project success afterwards (Naryan, 1995; Isham et al., 1996). The model developed above suggests that effect of project decisions taken prior to, during or right after project construction, may be introduced in an manner analogous to project appropriation i.e. as affecting the productivity of capital and labor maintenance contributions.

Let $\{D_1, \dots , D_M\}$ denote the M project decisions, ranging from deciding the type of project to the details of project usage rules and maintenance system. Let $\{\delta_1, \dots,\delta_M\}$ where $\delta_i>0$ and $\delta_i \in [\underline{\delta},\overline{\delta}]\ \forall i$, capture the effect of these decisions on maintenance input productivity, where each δ_i is a determined by investments of local and technical information. In the reduced from of the maintenance/benefit function above, this implies that $B = f((1-\alpha)\prod_{j=1}^{M}\delta_j\sum_{i=1}^{N}[l_i + m_i])$.

To illustrate this productivity effect, consider a decision regarding the site of a project that ignores local information. The decision may result in the project being made in a part of the community that is more at risk of landslide damage than an alternate project site would have been. As a result, community investments in project maintenance will be less productive now i.e. a greater level of investment will be required to maintain the project in a given state, as it suffers damage more often.

The two agents involved, the community and the external organization, have different skills to offer. The community has a comparative advantage in local information and the external organization in technical information. Participation in a decision is introduced both as a means of influencing the eventual decision taken, and as an investment of the participating agent's information. The former implies that, as community participation in a decision increases, it is more likely that the eventual decision taken will give more weight to the community's preferences. Let community participation in decision *i* be P_i^C and external organization participation, P_i^E. Decisions vary in their sensitivity to the two types of investment; non-technical decisions are more responsive local information and technical decisions more sensitive to technical information.

The community not only values net project return, but also cares about how the project affects the community indirectly. For example, in deciding project design, a consideration the community may have is that the road does not pass through the old cemetery even though this area is least at risk of flooding. Overall community return is now given by $\pi B(.)+(1-\pi)V(.)$ where V(.) is the community's return from indirect project effects, and $\pi \in [0,1]$, is a weighting factor. Note that V(.) is a function of local information only. The model does not take a stance on the interpretation of V(.). It may be of real value to the community, as in the example above, or a result of mistaken community beliefs. For example, a community may be unable to assess the quality of a lift-pump and buy the cheaper unbranded pump since it makes less noise. Similarly, the external agency's overall return is a weighted average of B(.) and Q(.), where the latter denotes the valuation derived from project "technical quality" and is a function of technical information only. This incorporates the tendency amongst engineers in the external agency to "over-value" technical attributes of the project, as has been noted in the field, such as having concrete culverts in road projects when they may not be crucial (Tendler, 1993, 1996).

Claim 3: *Increased community participation in non-technical project decisions taken before, during or after project construction, improves project maintenance. However, greater community participation in technical decisions worsens project maintenance.*

Intuition: The first part of the claim follows from the greater sensitivity of non-technical decisions to local information. Increased community participation implies that the community's preferences are given more weight in the decision making process. Since the community's overall benefit function values local information relatively more, community participation leads to greater local investment, and therefore higher maintenance input productivity. For technical decisions, the opposite holds: greater community influence in the decision lowers maintenance input productivity since the decision is based more on local than technical information. Implicit in this claim is that community participation has a real influence on the decision i.e. greater community participation makes it less likely that the decision is determined by the external agency. Table 9 supports this assumption. Columns 1-5 show that for all but one of the technical project decisions, higher community participation in the decision also implies a lesser likelihood that the external organization rather than the community is identified as the main decision maker.

4. Data and Empirical strategy

4.1 Data

Detailed technical, financial, and demographic information was collected on 132 infrastructural projects in 99 communities in Baltistan. The communities are either villages or *mohallahs* (sub-villages) and were selected using a random draw from the population of communities where the Aga Khan Rural Support Programme (AKRSP) has projects. Since the NGO has 92% coverage in the region, this population is fairly representative of the region. Figure 3 shows a map of the region, indicating the selected communities and Table 1 gives the break-up of the sample by type of project. While each selected community was guaranteed to have an AKRSP project, a second project satisfying the selection criteria was found in only 33 communities. The project selection criteria used were that the project be one of the seven types, and its maintenance be the responsibility of the community alone.

The survey was carried out in 1999 and consisted of four separate questionnaires. Trained enumerators administered the first three to the community: A detailed group questionnaire, five individual questionnaires and a hereditary leader questionnaire. A team of engineers undertook the fourth, a technical questionnaire.

The *group questionnaire* includes a community and a project section. The first gathers information on community demographics, and the second, on details of the project(s) selected from the community, such as the level and distribution of project costs and benefits, participation in project decisions and project maintenance. This questionnaire was administered to a group of community members, with care taken to ensure the group was balanced and representative of the community. In addition, five community households were randomly selected (geographical stratification) for the *individual questionnaire,* which explores sensitive issues such as community conflicts, fund mismanagement and individual participation in project decisions. The *hereditary leader questionnaire* was administered to an adult member of the hereditary leader household and gathers demographic information on the household.[8] The *technical survey* consisted of site visits made by engineers, to assess the project's physical condition, maintenance system and operational state. Questions were tailored to each of the seven project types. As an example, for irrigation channels, questions were asked regarding bed seepage, side-wall breaks, and discharge. For electricity projects, questions ranged from checking the turbine blades to the noting the condition of the head-pipe. Any financial constraints and design flaws in project construction were also noted.

Altogether, the four primary surveys and various secondary sources provide information on project outcome measures (physical and operational condition, maintenance work), community variables (community land, income, education, level of development, inequality, social divisions, wages, migration, conflict, hereditary leadership, natural disasters), project variables (project type, scale, expenditure and construction details, age, complexity, skill requirements, design flaws, external organization details), project net benefits/need (level and distribution), and community participation in project selection, planning, construction and maintenance decisions.

Table 2 presents the descriptive statistics. Central variables are constructed using multiple questions and information sources to ensure validity and reliability. The project maintenance measure described below is based on independent measures obtained through the group and technical questionnaires. Project *physical, functional and maintenance-work scores* are three complementary measures of maintenance available. *Physical score* estimates the percentage of the project that is in its initial physical state. A score of 70 means the project is in 70% of its initial condition, or alternately, that it requires 30% of the initial (real) investment

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[8] The questionnaires are available in PDF format at *www.economics.harvard.edu/~akhwaja/quest.html*

to restore it to the initial condition. Functional and maintenance-work scores have similar interpretations: *Functional score* captures the percentage of the planned project needs satisfied, and *maintenance-work score* estimates the percentage of project maintenance needs met.[9] The latter two, while more subjective, provide useful complements to physical score. Table 3 shows that all three scores are highly, though not perfectly, correlated.

Each score is constructed using three independent sources to ensure accuracy. For example, an irrigation channel's physical score is constructed as follows: The initial score is based on 10 questions in the group questionnaire. The score is then verified using the enumerator's site visit notes, and combined with the third independent source – the technical survey, administered at a different time from the enumerator survey. Nevertheless, it is comforting to note that the correlation between these sources was more than 0.6 for all three scores. It is also worth emphasizing that the scores incorporate both community-reported and technical assessments of maintenance. Using only a technical measure ignores the community's own perception. To illustrate, a technical assessment of an irrigation channel may wrongly penalize the community for not carrying out a side wall repair with cement, even though the members correctly decided the repair could just as effectively and be carried out by mud and stones, since the water pressure in the channel was low. On the other hand, using only a community reported measure suffers from possible community mis-reporting. In contrast to previous studies, these scores represent a more accurate attempt to measure maintenance, and hence collective success. *Total score*, the primary outcome measure, is an average of the three scores.[10]

Project share inequality measures the inequality in *observed* division of project returns; for example, in an irrigation project, it is the inequality in land holdings in the command area of the project. As suggested in the theory section, project share inequality is one possible determinant of project return inequality, the unobserved theoretical measure of inequality in *realized* returns from the project. *Land inequality*, another such determinant, measures the inequality in the distribution of land holdings across households in the community. Both measures are similar to Gini coefficients; the only difference is that they are based on grouped rather than individual data. For example, to calculate land inequality, a standard Gini coefficient would require an estimate of how much land each community household owns. However, land measures are extremely hard to obtain in Baltistan as land is highly fragmented, spread over a large area, and in hazardous terrain. These considerations rule out the feasibility of this approach. Instead, the land inequality index is constructed using grouped data: Households with the maximum and minimum land holding in the

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[9] Optimal maintenance needs vary depending on the type of the project and this was taken into account using engineer-based technical judgements.

[10] The empirical results do not vary significantly if the three scores are instead used separately as measure of collective success.

community are identified. Using the two land holding sizes, three equal land holding bins are created, and the number of households belonging to each bin noted. Since all households are distributed in one of the three bins, a grouped-Gini inequality index can be constructed.[11] *Project share inequality* is constructed similarly.

Social heterogeneity is an average of the fragmentation indices based on clan, religious and political divisions. The indices are constructed as is standard in the literature (Alesina and La Ferrara, 1999); each index is the probability that two people randomly chosen from the community belong to a different (clan, religious or political) group. Mathematically, the index is $1-\sum_k s_k^2$ where s_k is the proportion of the k^{th} group in the community. Higher values of the index represent greater heterogeneity.

Project benefit is calculated by estimating net annual returns for each project. For example, for an irrigation project that irrigates new land, net benefit is estimated by considering the amount of new land cultivated under the project and then valuing the actual crops grown on that land using price and cost estimates obtained from local agricultural support departments. Since the benefit measure is at best a rough approximation to actual benefits and extremely noisy, it is not used as an outcome measure. Instead, it is used in a bivariate regression with project maintenance to provide a monetary equivalent to maintenance. Doing so reveals that a 10 percentage points increase in maintenance translates into a $26 annual household gain.

Several other variables in Table 2 are central to the subsequent empirical analysis. *Project leader* is a binary variable that indicates whether the project has a leader or not. Project leaders are individuals who may be selected by the community to manage and be responsible for the project. Leader selection is based on considerations such as the individual’s status, seniority, influence, and abilities. A natural choice for a leader is often the hereditary leader or traditional headman of the community (*trampa*). The role of leaders is to either directly look after the project as a watchman,[12] or indirectly, as the head of a committee responsible for project upkeep. Care was taken in the interviewing process that the presence of a leader was not identified on the basis of project performance. *Leader quality* is an average of the five community individuals’ binary evaluation of the project leader’s quality (good or bad).

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[11] An alternative is to calculate a standard Gini coefficient using land-holdings of the five households in the individual questionnaires. While this is also done, and the Gini coefficient constructed correlates well with the inequality index (0.89), the latter is preferred since it offers a more reliable, albeit coarser, measure of community land inequality; the group index includes *all* community members and is therefore less sensitive to outlyers. Moreover, the problem of mis-reporting or mis-measuring land size is less troublesome in the group-reported inequality measure, since any bias is likely to be the same for all members, which would not be the case if they were asked individually.

[12] Watchmen are common in irrigation channel and boundary wall projects. Their duties range from regularly checking the project, and conducting minor repairs to alerting the community in case larger repairs are needed. They are usually paid in kind rather than in cash.

Project Complexity ranges from 0-3, where the index is increased by one each if: (i) the project has greater cash (for outside labor and materials) versus non-cash (local labor and materials) maintenance requirements, (ii) the community has had little experience with such a project, and (iii) the project requires greater skilled labor or spare parts relative to unskilled labor for project maintenance. *Project New* is a binary variable that is 1 if the project is new, and 0 if it is a continuation project (a project made as an extension to an existing community project). While the extension work for a continuation project can be minimal, in general the existing project is a small community-made project and the external organization then spends substantial funds extending it. A typical example of such work is modifying an existing mud-walled irrigation channel by cementing the bed, lining the walls with stones, and extending the length of the channel. *External organization* is a dummy variable indicating the type of external organization involved in project construction. The primary external organization comparison is between the local government and AKRSP projects. There are a few other semi-governmental external agencies in the sample, but they have too few observations to allow any meaningful comparisons.

Table 4 gives summary statistics for *community participation* in project decisions, grouped by non-technical and technical decisions. The five respondents in the individual questionnaire were asked whether their household (directly) participated in the given decision; the participation measure is the percentage of those who answered yes. Technical decisions show higher participation as they also include indirect participation i.e. whether the household responded that it participated through a representative. Indirect participation is included for technical decisions since both direct and indirect community participation will have a negative effect on maintenance, as they crowd out external organization participation. In the case of non-technical decisions, only direct participation is considered, as indirect participation is not a good measure of maximizing community participation and knowledge. Nevertheless, including or excluding indirect participation in either decision category, does not significantly affect the empirical findings.

4.2 Empirical Strategy

Basic Model:

The model in section 3 provides the basic estimation equation. Assuming a logarithmic specification for the maintenance/benefit function results in a separable form that determines project maintenance, M_{ip}, for the p^{th} project in the i^{th} community:

(2) $$M_{ip} = A_{ip}\beta_1 + Pc_{ip}\beta_2 + I_{ip}\beta_3 + \varepsilon_{ip}$$

where A_{ip} is denotes characteristics determining the degree of capital appropriation, such as project capital requirements, experience and leadership. Pc_{ip} denotes community participation in various project decisions, and I_{ip}, project return inequality. The vectors β_1, β_2 and β_3 are parameters to be estimated and $\in_{\mathrm{ip}}$ is a normally distributed error term with mean 0 and constant variance. Equation 2 is derived in the Theory Appendix.

As noted in the theory section, project return inequality is determined both by inequality in the distribution of observed division of project returns (*project share inequality),* such as the land distribution in the command area of an irrigation project, and by community-specific measures that capture the relative influence of households. In the context of Baltistan, two prominent factors that determine a household's influence are its relative land holding (*land inequality)* and social strength (*social heterogeneity).*

Based on Claim 1, both project share and land inequality are expected to have a U-shaped effect on maintenance. However, social heterogeneity may not have such an effect, despite working through the same project return inequality channel in Claim 1. The difference arises because social heterogeneity does not map linearly into project rights inequality. For the two inequality measures, increases in inequality are expected to monotonically increase projects rights inequality as well. However, while moving from low to intermediate levels of heterogeneity does worsen the distribution of power, as the rights of minority social groups are appropriated, this relationship does not hold monotonically. Further increases in heterogeneity have an offsetting effect, as the greater group diversity also implies that any one group is smaller and less able to appropriate the others.

Figure A below illustrates the above relationships between the three measures and project return inequality. It is also plausible that project return inequality is more sensitive to project share inequality than to land inequality, since the former is a direct determinant of realized project returns while the latter influences realized returns indirectly. Thus, in order for a household to command a larger share of realized returns from an irrigation project without owning greater land in the irrigated area, it would have to wield a substantially large influence in the community.

Figure A: Hypothesized relationships – Inequality measures and maintenance

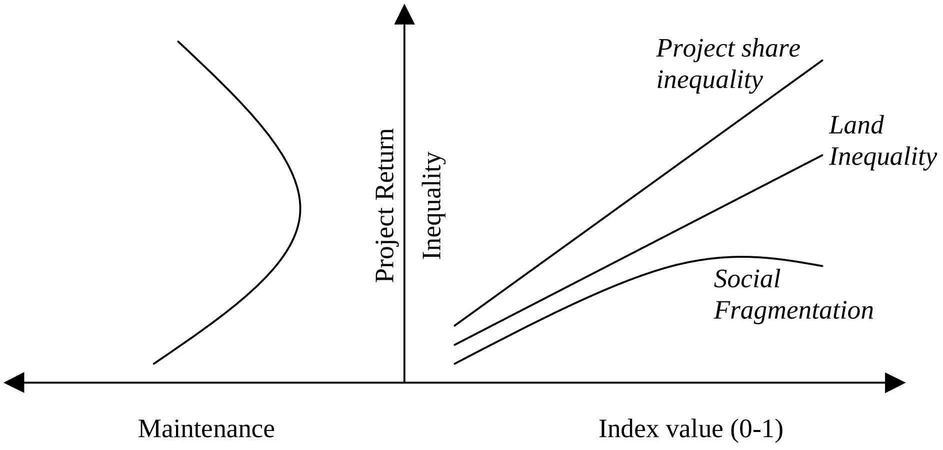

Figure A also graphs the relationship between project return inequality and project maintenance as in Claim 1 in the theory section. Taken together, Claim 1 and the above relationships suggest the following:
Conjecture: *For a standard community project, both project share and land inequality have U-shaped effects on maintenance while social fragmentation has a negative effect. Moreover, the positive segment of the U-shaped effect for the two inequality measures is larger for project share than land inequality.*

Equation 2 can be expanded further in light of the theoretical claims in section 3 and above conjecture. Linearity follows from an approximation to equation 2.

$$\begin{aligned} M_{ip} = {} & Lead_{ip}\beta_1^1 + Complex_{ip} * Lead_{ip}\beta_1^2 + Complex_{ip}\beta_1^3 + TechPc_{ip}\beta_2^1 + nonTechPc_{ip}\beta_2^2 + \\ & PjIneq_{ip}\beta_3^1 + (PjIneq_{ip})^2\beta_3^2 + LIneq_i\beta_3^3 + (LIneq_i)^2\beta_3^4 + SocHet_i\beta_3^5 + (SocHet_i)^2\beta_3^6 + \varepsilon_{ip} \end{aligned} \tag{3}$$

where $Lead_{ip}$ is the presence/quality of project leadership (*project leader* and *leader quality* in Table 2), $PjIneq_{ip}$ is project share inequality, $LandIneq_i$ is land inequality, and $SocHet_i$ is social fragmentation. $Complex_{ip}$ is the *project complexity* measure, and $TechPc_{ip}$ and $nonTechPc_{ip}$ are community participation levels in technical and non-technical project decisions respectively.

The data includes other community and project-specific factors in addition to those suggested by the theoretical model. Equation 4 presents the general estimation model.[13]

$$M_{ip} = \mathbf{P_{ip}}\beta + \mathbf{X_i}\alpha + T\lambda + \eta_{ip} + \nu_i \tag{4}$$

where $\mathbf{P_{ip}}$ is a vector of project-specific variables; project return inequality, leadership and complexity as above, but also project age, external organization type and whether the project is new. $\mathbf{X_i}$ is a vector of community-specific factors including land inequality and social heterogeneity, community size, remoteness, infrastructure, and demographics. T is a project type dummy and η_{ip} and ν_i are the error terms. The latter represents a community-specific error term capturing community variables not included in $\mathbf{X_i}$. Equation 4 includes both the quadratic and interaction terms suggested by the theory and detailed in equation 3.

Estimation Issues:

Equation 4 can be used to estimate the effect of community-specific factors using ordinary least squares (OLS) assuming that these factors are uncorrelated with the error terms. However, a particular concern in estimating the effect of project-specific factors is that they are likely to be correlated with the community-specific error term. Specifically, $corr(\mathbf{P_{ip}}, \nu_i) \neq 0$.

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[13] Since the other variables are not modeled, separability can no longer be guaranteed. Equation 4 can be interpreted as a first order approximation to the complete model.

An example of such a bias arises when examining the effect of external organization type. External agencies are likely to have different criteria for selecting communities in which to work – an NGO may work in poorer communities, whereas the local government may prefer politically influential communities. In so far as these communities differ along unobservables, an external organization effect in equation 4 is confounded by an unobserved community quality effect. Similarly, community participation in the project may also be correlated with the community-specific error term, since it is likely to include unobservable community characteristics that cause communities to participate more.

Nevertheless, provided that *corr*($\mathbf{P}_{\mathbf{ip}}$, η_{ip})=0, the effect of project-specific factors can still be identified using community fixed effects. Specifically, the first difference equation given below provides correct estimates as it differences out the problematic community-specific error term:

$$(5) \qquad M_{i1} - M_{i2} = (\mathbf{P}_{\mathbf{i}1} - \mathbf{P}_{\mathbf{i}2})\beta + T\lambda + \eta_{i1} - \eta_{i2}$$

where the second subscript denotes the value of the variable for the first or second project i.e. M_{i2} is the maintenance score for the second project in the ith community.

Since one-third of the communities in the data have two sampled projects each, equation 5 is estimated in this sub-sample. A possible concern is that this leads to a sample selection bias; communities with two sampled projects are different from those with only one. While mean comparison tests reveal that the two community types differ in size (two-project communities are larger), they do not differ in any other community characteristics, particularly social heterogeneity and community inequality. Moreover, the point estimates for community-specific factors in the sample of only two-project communities are similar to those in the full sample, although the standard errors are understandably higher in the former. Thus the sample selection problem in estimating equation 5 does not appear to be a serious concern.

A remaining issue arises in identifying the effect of project leader presence. While project leadership is correlated with the community-specific error term (good communities are more likely to select and agree upon a person to manage the project), it also suffers from a project-specific bias; projects that are doing well are more likely to attract and afford a leader. The latter bias implies that *corr*($\mathrm{Leader}_{\mathrm{ip}}$, η_{ip})≠0 and therefore the fixed effects estimation above can no longer identify the leadership effect. However, the effect can still be identified using two stage least squares (IV-2SLS). Both stages of the estimation and details of the instruments used will be discussed in section 5.

5. Results

5.1 Community-specific Factors

Table 5 presents the OLS estimates for equation 4. In addition to community characteristics such as inequality and heterogeneity, the regression also includes measures of the community's human and physical capital, project-type fixed effects, and controls for project-specific factors. The main results for the community-specific factors are discussed below.

Land Inequality has a U-shaped effect on maintenance. A 0.1 unit increase in the land inequality index starting from perfect land equality is associated with a 24 percentage points fall in maintenance. The same increase at a higher inequality level of 0.4 (90th percentile) is associated with an 8.1 percentage points rise in maintenance. The result is robust to project and community-specific controls. As described in the section 2 above, land settlement patterns are fixed and land markets non-existent in Baltistan. Therefore, OLS provides consistent estimates.

Social Heterogeneity has a negative effect on maintenance. An increase in the heterogeneity index from the 1st to 3rd quartile (0.25 to 0.43) is associated with a 9.6 percentage points drop in maintenance.[14] In addition to the theoretical channel described in this paper, increased heterogeneity may hinder collective action by weakening social norms and sanction mechanisms. Preference-based arguments also explain lower participation and worse collective performance in heterogeneous communities (Alesina and La Ferrara, 1999). As Table 5 shows, the adverse impact of heterogeneity is robust to project and community-specific controls, particularly land inequality. Since social heterogeneity in the community is expected to be exogenous to project maintenance, as suggested in section 2, OLS provides consistent estimates.

Having a *project leader* has a positive effect on maintenance.[15] Table 5 presents the OLS estimates: Projects that have a leader are associated with 11.3 percentage points higher maintenance than projects without leaders. As discussed in section 4 above, the OLS estimate is expected to be biased upwards since leaders are more likely to be present for good projects and in good communities.

Table 6 presents the IV estimates for project leader presence. As described in section 2 above, most communities in Baltistan have *trampas* (hereditary leaders). Information on the characteristics of these hereditary leader households was gathered to provide instruments for project leader presence. Hereditary

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[14] No significant quadratic effects were found; the conjecture in section 4.2 also suggested weak quadratic effects.

[15] While project leadership is in theory a project-specific factor, in practice it is primarily determined by community-specific factors. Moreover, the instrumentation strategy used relies on community-specific attributes. Thus, project leadership is treated as a community factor.

leaders are not selected by the community but are, by tradition, a natural choice to lead. It is probable that a member of these households either directly becomes the project leader, or influences the decision to have a project leader. Exogenous attributes of the hereditary leader household, such as whether it has a young and healthy male member (a "potential" leader), provide possible instruments as they are unlikely to be correlated to the project and are correlated with having a project leader or not through other channels. The instruments used are: (i) an indicator variable for whether the household has a healthy male member between the ages of 25 and 50, (ii) the average age of household members, and (iii) the average index of household members' presence in the community (1 = a lot, to 3 = very little). The first two variables are based on demographic "shocks" to the household and are therefore exogenous, while the third, conditional on community demographics, is also expected to be independent of project maintenance. Column 1 in Table 6 presents the results of the first stage. The likelihood of having a project leader increases by 35% if there is a healthy male between 25 and 50, by 19% for a 1st to 3rd quartile increase in average household age, and by 12% for a 1st to 3rd quartile increase in household presence (magnitudes are based on a probit regression). The instruments are jointly significant at less than 1%.[16] Column 2 presents the second stage and shows that an increase from the 1st to the 3rd quartile in the predicted value[17] of having a project leader increases project score by 7.6 percentage points.

A potential issue in the above IV estimate is that leader presence is confounded with leader quality. Column 3 in Table 6 shows that, conditional on having a leader, there is a negative effect on maintenance if the leader belongs to the hereditary leader group. This implies that the above IV specification underestimates the leader presence effect, since the instruments predict the presence of a low quality leader. A possible solution is to control for leader quality. However, the quality ranking measure (*lead quality* in Table 2) suffers from the same endogeneity issues as leader presence and needs to be instrumented for. Column 4 in Table 6 presents the first stage: Leader quality rises by 10% if the hereditary household has a healthy male member between 25 and 50 years old, who has at least primary education and is always present in the community. Leader quality falls by 20% if the hereditary household is involved in an off-farming profession (a proxy for disinterest in community affairs), and rises by 13% for a 1st to 3rd quartile increase in the number of individuals in the community perceived as being "ideal" potential leaders. The instruments are jointly

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[16] An issue in the IV estimate is that not all communities have hereditary leaders (28 of the 99 communities do not). The instruments are suspect if these communities differ from those with hereditary leaders. Mean comparison tests show that the two types of communities do not differ significantly in community observables. In addition, observations suggest that hereditary leader presence is determined by where the hereditary leader was residing during the 1970 land reforms, after which he no longer commanded formal authority over a set of villages but remained restricted to his village of residence. This difference is unlikely to determine project maintenance. Moreover, the second stage estimates presented for the full sample (the first stage interacts each variable with an indicator for hereditary leader presence) are similar to estimates in the restricted sample, which only includes communities with hereditary leaders (not shown).

[17] Since the presence of a project leader is a binary variable, instrumenting for it results in a continuous predicted value between 0 and 1. The comparable effect to the change of the binary variable from 0 to 1 is estimated by considering an increase in the predicted value from its 1st to 3rd quartile.

significant at less than 1%. Column 5 in Table 7 presents the second stage of this IV estimate. While the leader presence effect is reduced to 5.9 percentage points, a 1st to 3rd quartile increase in leader quality raises maintenance by an additional 7.5 percentage points. Thus Table 6 shows that not only does the leadership effect remain after correcting for the upward bias in the OLS estimate, but even low quality leaders have a positive effect on maintenance.

Other Findings:

Table 5 also considers other community-specific factors: *Community size* has no significant effect once land inequality and social heterogeneity are controlled for, suggesting that it is not size per se that matters, but the greater inequality and heterogeneity in larger groups that hinders collective action. *Total cultivatable land* holding in the community has no significant effect, while *single cropping* communities (those with one yearly harvest) are weakly associated with 8.8 percentage points lower maintenance. *Community remoteness* measures (distance and travel time) do not have any significant and consistent effect. A 1st to 3rd quartile (3 to 11%) increase in the fraction of *shopkeepers* in the community is associated with a 5.9 percentage points drop in maintenance, while the same quartile increase for the *skilled workers* fraction (4 to 16%) is associated with a 3.8 percentage points rise.

The fraction of those with *basic education* (primary to secondary) has a negative insignificant effect. However, a 1st to 3rd quartile increase (0 to 10%) in the fraction of *tertiary* educated (at least 12 years of schooling) is weakly associated with 3.9 % points higher maintenance. A 1st to the 3rd quartile (2 to 10%) increase in the fraction of those with *religious education* is weakly associated with 3 percentage points lower maintenance. Communities that have a *high school* (upto 10th grade) are associated with 20.6 percentage points higher maintenance, as compared to those that have only a religious, primary, secondary (up to 8th grade) or no school at all. Average *off-farm household income* and *community wage* rates have no consistent effect. However, each additional household that owns *mechanized assets*, a measure of the community's productive capital base, is associated with a 2.1 percentage points increase. In contrast, an increase in *average real estate value* from the 1st to 3rd quartile (Rs 70,000 to 200,000 - US$1300-3600) is associated with a 5.7 percentage points fall in maintenance. There is a weak positive effect of having *electricity* in the community (a 5.1 percentage points rise), but no consistent effects of *potable water* and *health* facilities.

5.2 Project-specific Factors

Table 7 presents the results from the regression specification with community fixed effects (equation 5). As discussed in section 4, this estimation identifies the effect of project-specific factors. All results are robust to project age and other project-specific factors. The regressions also include project-type fixed effects.

Project complexity has a negative effect on maintenance. Table 7 shows that a 1st to 3rd quartile increase in the complexity index is associated with a 25.5 percentage points drop in maintenance. This is in contrast to the smaller 8.4 percentage points effect in the OLS specification. The latter estimate is expected to be biased downwards as less able communities are likely to opt for simpler projects. Anecdotal evidence also suggests that the complexity effect is driven by the risk of appropriation rather than capital shortages, as modeled in section 3. While cash constraints were offered as the initial reason for failure to maintain and run the lift irrigation pump in village Kehong Kowardo, the community is located near the regional capital with wages in the 95th percentile of sampled communities, and is unlikely to suffer from such shortages. Further inquiry revealed that the individual responsible for collecting cash had been successfully operating his private irrigation pump for several years. When asked why he didn't face cash shortages despite being an average-wealth community member, he conceded the real problem was not that community members faced cash constraints, but that they were unwilling to provide cash. Members explained they preferred not to give cash, as they were unsure of how it was spent. The project had stopped being used due to disagreements regarding where the contributions had been spent and whether the reported expenditure had been necessary or had even taken place. The community maintained that projects that didn't require regular cash contributions would work better, even if they needed an equivalent amount of labor.

Project share inequality has a U-shaped effect on maintenance. Figure 4 plots residuals from a regression of the maintenance measure (total score) on community dummy variables, project age and type in the restricted sample of communities with multiple projects. The plot reveals the U-shaped relationship between project share inequality and maintenance.[18] The conjecture in section 4 suggests that the positive part of the U-shaped effect is larger for project share inequality than land inequality. This is supported in the data. Table 7 shows that increasing inequality by 0.1 units from perfect project share equality, lowers maintenance by 24 percentage points. The same increase, starting from a higher inequality level (0.4), raises maintenance by 80 percentage points. This result lends credibility to the theoretical effect of inequality on maintenance in section 3, as compared to the effects proposed in purely preference-based models. These "social capital" models argue that cooperation is difficult in unequal communities since members of different social, economic or ethnic classes prefer to associate with members of their own class. However, once all community-level inequality measures are controlled for, as in Table 7 (due to community fixed effects), these models are hard put to explain any project-specific inequality effects. In contrast, the theoretical channel described in section 3 illustrates the importance of inequality in realized project returns, which is determined *both* by community and project-specific inequality.

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[18] The two high project share inequality outliers in Figure 6 do not affect the residual plot (the U-shaped relationship remains as strong) or the estimates, and are retained to improve standard errors.

Community participation in *non-technical project decisions* positively affects maintenance, but has a negative effect in *technical project decisions*, as hypothesized in section 3. Table 7 shows that a 10% increase in community participation in non-technical decisions is associated with a 5.5 percentage points rise in maintenance, but the same increase in participation in technical decisions is associated with a 3.8 percentage points fall in maintenance.[19] This result stands in contrast to the existing literature that views community participation as an unqualified good (Narayan, 1995; Isham et al., 1996).

While the community fixed effects estimates in Table 7 correct for the endogeneity problem arising from community unobservables inducing greater participation, "halo effects" remain a concern. Since the participation measures are based on recall, even if a decision occurred prior to project maintenance, individuals may falsely report participation (no participation) if the project is currently doing well (poorly). Such halo effects would lead to an overestimate of the participation effect. The ideal solution is to instrument for participation, but plausible instruments are hard to come by. An alternate strategy is to check whether halo effects are actually present. This can be done since the five community members surveyed in the individual questionnaire are also asked to rank their perception of the project's current physical and operational state. Were halo effects significant, individuals who perceive the project to be in a better state relative to the others surveyed in the community, would also report relatively higher participation. Columns 6-7 in Table 9 check for this positive correlation implied by halo effects, and find none for either the physical or operational measure of project maintenance. Therefore, halo effects do not seem to be present in the data.

A concern that cannot be addressed arises since community participation is, after all, a choice outcome. To the extent that the project specific factors that affect this choice are not controlled for, causality cannot be guaranteed. Thus, while community participation has a negative or positive effect on maintenance based on whether the decision is technical or not; causality can only be suggested by using community fixed effects and showing that halo effects are not important.

External organization type has a significant effect; NGO (AKRSP) projects do better than local government projects. Table 7 shows that NGO initiated projects are associated with 22 % points higher maintenance as compared to projects initiated by the local government. The project type and complexity controls allay a possible concern that the effect is caused by the NGO constructing simpler projects. In fact, as Table 11 shows, the NGO constructs more complex projects. Another concern is that the effect is an initial construction quality effect; the NGO constructs better projects and so, regardless of the community's maintenance effort, the projects remain in a better state.[20]

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[19] Similar results hold if the decisions that are grouped in the non-technical and technical categories (see Table 4) are considered individually (regressions not shown).

[20] This result would still be interesting since overall expenditure by the two agencies is controlled for. However, since such an effect is not a determinant of the community's collective success, it is not emphasized in this paper.

Table 10 shows that this is unlikely to be the case. Column 1 shows that the NGO effect is robust to the inclusion of the amount of funds invested by the external organization, and a community ranking of project construction quality. Table 10 offers another test for the initial construction quality explanation. The ideal test would control for quality measures made by engineers at the time of project construction. No such measure is available, as the one used in Column 1 is community-reported. However, if the construction quality explanation is true, it must be that current physical score is determined primarily by construction quality, and therefore, *physical score* provides an accurate measure of construction quality. The test regresses project *functional score* on project-specific factors, controlling for *physical score.* Columns 2 shows that NGO projects have 26 percentage points higher functional scores. Thus, not only do NGO projects outperform government ones in terms of the aggregate performance measure (*total score)*, but, controlling for current physical condition, NGO projects are also used more effectively i.e. meet a greater fraction of the planned needs. Together, Columns 1-2 offer strong evidence that the NGO effect is more than just a construction quality or higher funds invested effect.

Another concern is that the effect is a result of greater overhead costs incurred by the NGO. While project-wise data on overheads was not possible to obtain, information collected at the NGO and government offices suggests that the two agencies do not differ in overheads, but do differ in the distribution of such costs; while the local government employs more staff it pays them lower salaries. This hints at lower incentives in the local government offices. Other explanations may be that the NGO is more aware of the local environment and needs, is less prone to corruption, has greater accountability and transparency, attracts a more dedicated staff, or elicits greater community participation. The data is unable to distinguish between these hypotheses. It supports some – NGO initiated projects are 35% more likely to have a project leader and have 20% higher community participation in project decisions – but, as column 3 in Table 6 shows, the NGO effect is only reduced slightly if leadership and participation are controlled for. Nevertheless, the results do show that NGO projects are substantially better maintained than local government ones, and this difference is not driven by the NGO spending more or constructing better projects.[21]

Continuation projects are maintained much better than *new projects*. Table 7 shows that continuation projects are associated with 41.9 percentage points higher maintenance than new projects. Since the estimate controls for project-specific factors, particularly project type and complexity, it is unlikely to be driven by new projects being of a different type or more complex. Alternately, continuation projects are likely to satisfy an earlier and possibly more important community need than a new project does. However, the effect is robust to the inclusion of perceived project need; controlling for community members' rank (1 to 4) of

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[21] Care must be taken in generalizing, since only one NGO is compared to a given local government. Moreover, the NGO, AKRSP, is an effective and high quality NGO, while the local government in Northern Pakistan is unlikely to be of above average quality.

project need does not lead to any change in the magnitude or significance of the effect (regression not reported). The interaction effects described below hint that continuation projects may be maintained better as they have already set up the systems and rules necessary to manage the project, an issue new projects have yet to tackle.

5.3 Interactions

Table 8 shows the results of various specifications that examine interaction effects. As predicted in the model in section 3, the *leader presence* effect is larger for *complex projects*. Due to the project leader presence and project complexity endogeneity problems mentioned above, an IV regression with community fixed effects is used to identify the interacted term. Column 1 shows the first stage which instruments for the interacted term by employing the same set of instruments used for leader presence (Table 6, Column 1) interacted with project complexity. Column 2 shows the second stage results: The leadership effect is 38 percentage points higher for complex relative to simple projects. Thus leadership matters primarily for complex projects. The explanation forwarded in the model is that leaders reduce appropriation, and since complex projects are more at risk of appropriation, they benefit more from having a leader.

Column 3 shows that *NGO projects* have 40.4 percentage points higher maintenance than local government projects, when comparing across *complex projects*. Column 4 shows that *new NGO projects* have 48.5 percentage points higher maintenance than *new local government projects,* and Column 5 shows that there are no significant interactions between *project complexity* and whether the project is *new* or not. The external organization interactions show that NGOs do better than local governments in complex and in new projects. Since new and complex projects require setting up management systems and transmitting new skills, this hints at the channels through which the NGO outperforms the local government. In addition, since there is no significant difference in performance between new-complex projects and new-simple projects, this result, combined with the previous interactions, suggests that continuation projects outperform new projects because new projects need to develop management systems, and not because they require new skills

5.4 Putting everything together

Table 12 below compares the effects of the main community and project-specific factors. The first column lists the determinant, and the second and third columns give the theoretical and estimated effects respectively. The magnitudes are percentage points change in maintenance for an increase from the 1st to 3rd quartile in the determinant, unless noted otherwise, or in case the determinant is discrete. The preferred estimation strategy for each determinant is listed in the fourth column, and the last column indicates the table that has the full regression. As described in the section 4, a 10 percentage points increase in maintenance results in a $26 net household gain – the equivalent of a 1.7% increase in average per-capita income.

Table 12

Variables	Predicted Effect	Estimated Effect (% points)	Preferred Estimation Strategy	Table
Community factors:				
Land Inequality	U-shaped	–24 *(0 to .1)* +8.1 *(.4 to .5)*	OLS	5
Social Heterogeneity	–	–9.6	OLS	5
Leader presence	?	+7.6	IV-2SLS	6
Project factors:				
Project Complexity	–	–25.5	FE	7
Project Share Inequality	U-shaped (large +)	–24 *(0 to .1)* +80 *(.4 to .5)*	FE	7
Non-technical participation	+	+14.7	FE	7
Technical participation	–	–18.5	FE	7
Government project?	.	–22	FE	7
New project?	.	–41.9	FE	7

A comparison of the point estimates show that the project-specific factors have a larger impact on maintenance than community-specific factors. Figure 5 illustrates this for the two U-shaped inequality effects. An F-test also reveals that the difference between the impact of these groups of factors is significant at the 5% level.[22]

Figure 6 provides another relative comparison. The figure plots the highest and lowest predicted project scores for each project in the multiple project communities by setting project complexity, community participation, external organization type, share inequality and whether the project is new or not, at their "best" and "worst" within-sample values. The predictions are based on the estimates in Table 7. While the figure is hypothetical and ignores the relative costs of manipulating project-specific factors, it nevertheless illustrates the importance of these factors. The difference between the highest and lowest project scores under a given design scenario (for example, points 2w and 1w in Figure 6) gives the largest community fixed effect i.e. the difference in performance between the best and worst community (the fixed effect captures all community-specific factors, observable or not). This difference is comparable to the difference between performance for the best and worst project designs for a given project (points 1b and 1w). Thus Figure 6 shows that the best-designed project in the worst community does just as well as the worst-designed project in the best community. This suggests that project-specific factors can indeed more than compensate for adverse community-specific factors.

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[22] The test constructs 95% a confidence interval for the joint effect of 1st to 3rd quartile increases (discrete if variable is binary) in the main community-specific factors, and a similar confidence interval for the joint effect of project-specific factors. The lower bound of the project-specific interval lies above the upper bound of the community-specific interval, providing the basis for the F-test claim.

6. Conclusion

Previous empirical work has examined the effect of social capital factors such as inequality and social heterogeneity on collective action. The results of this paper confirm these effects, and show that they are robust to a larger set of community and project controls than used in previous studies. This paper also adds to the literature by examining the effects of leadership and showing that leaders play an important positive role in determining collective success.

The magnitude of the estimated effects and the large variation in maintenance within communities, suggests rethinking the effect of community-specific factors, such as social capital, on collective performance. The estimates for all project-specific factors, except project leadership, are obtained by comparing the factor's impact on different projects in the *same* community. This provides the following two categories: those determinants that are inherent to the community (land inequality, social heterogeneity and leadership) and those determinants that are part of project and institutional design (project complexity, share inequality, community participation in project decisions, whether the project is new, and type of external organization). Comparisons show that the latter has, both economically and statistically, significantly larger effects than the former.[23] This suggests that, while social capital is indeed a stimulus to collective action, its scarcity can be compensated for by better project design.

Since social capital factors tend to persist over time (Putnam, 1993), they may be best viewed as constraints rather than policy tools. Land redistribution can be used as a means of influencing community inequality, but such reforms are notoriously hard to implement. Dividing the collective venture so that it involves more homogenous sub-groups can help, but doing so may increase unit costs substantially.

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[23] The data also collected direct measures of social capital such as community trust and conflict. Since these measures are best interpreted as outcomes, OLS estimates of their effect on maintenance are biased upwards. Nevertheless, these estimates support the relatively smaller magnitude of social capital effects: *Trust* (do members trust each other) has no significant effect. However, communities that report high unity have 8 percentage points higher, and those with land disputes, 13 percentage points lower maintenance. Communities that do not report problems in raising cash for collective work have 10 percentage points higher maintenance, but there is no significant effect for problems in raising community labor. While the number of community organizations (normalized by community size) has no significant effect, a 1st to 3rd quartile increase (1 to 2.6) in the total membership of community organizations (normalized by community size) is associated with 5 percentage points higher maintenance. The fraction of community households with temporary (seasonal) migrant members has no effect, but the analogous fraction for permanent migrants has a negative effect; a 1st to 3rd quartile increase (0 to 5%) worsens maintenance by 3 percentage points. A 1st to 3rd quartile increase (0 to 2%) in the fraction of community households that migrated recently into the community is associated with a 1 percentage points fall in maintenance. The estimates control for human and physical capital, and project-specific factors.

Therefore, rather than directly addressing the social capital constraint, policy initiatives that emphasize project design may be more feasible and have better success in implementation. This paper offers several such project-design improvements. Specifically, designing projects that face fewer appropriation risks (through better leadership and lower complexity), eliciting greater local information through the involvement of community members in project decisions, investing in simpler and existing projects, ensuring a more equitable distribution of project returns, and employing NGOs can substantially improve project performance even in communities with low social capital.

However, this paper also shows that a more detailed analysis is needed before concrete policy recommendations can be made. Forcing an equal distribution of ownership shares in the project can also reduce efficiency and, in such cases, "equitable" privatization may work better. For example, electricity generation units can be provided (sale or rental) to a few community individuals who are made responsible for project maintenance and allowed to charge user fees. The external organization can then put constraints on the user fees to ensure equity.

Similarly, the participation slogan prevalent in development policy also risks being misapplied; while greater community participation helps in most decisions, technical decisions may be best left to the external organization. The same is true for NGO delivery; while the NGO examined outperforms the local government, more detailed data is needed to identify features that explain the NGO effect. These features may not be inherent to NGOs, but could also be exploited by the local government, especially since the government has potentially greater coverage and resource leverage. The result that continuation projects are better maintained than new projects implies that new investments may not have a greater impact than continuation work, since they are also more likely to fail. The results also hint that continuation projects perform better because the community has already created the systems or "social capital" necessary to manage the project. This suggests that social capital may be specific to a particular task or range of tasks. Projects may therefore be designed to better exploit existing forms of social capital.

This paper has examined a wide range of determinants of collective action and contrasted their relative importance. The results show that even communities that face possibly inherent and persistent constraints, such as a lack of social capital, can achieve collective success through well-conceived and better-designed projects.

References

Afridi, Banat Gul. (1988). Baltistan in History, Peshawar, Pakistan: Emjay Books International.

Agarwal, Arun and Sanjeev Goyal. (1999). "Group Size and Collective Action: Third Party Monitoring in Common-Pool Resources," *Leitner Working Paper 1999-09,* Yale University.

Alesina, Alberto; Reza Baqir, and William Easterly. (1999). "Public goods and ethnic divisions," *Quarterly Journal of Economics,* 114**,** November.

Alesina, Alberto, and Eliana La Ferrara. (1999). "Participation in Heterogeneous Communities," NBER Working Paper #7155.

Betz, Mathew; Patrick McGowan, and Rolf Wigand. (1984) Appropriate technology : choice and development, Durham: Duke University Press.

Baland, Jean-Marie and Jean-Philippe Platteau. (1996). Halting Degradation of Natural Resources. Is There a Role for Rural Communities, Oxford: Clarendon Press.

Baland, Jean-Marie and Jean-Philippe Platteau. (1996). "Inequality and Collective Action in the Commons," CRED, University of Namur.

Baland, Jean-Marie and Jean-Philippe Platteau. (1998). "Wealth Inequality and efficiency in the commons. Part II: The regulated case," *Oxford Economic Papers*, 50, 1-22.

Banerjee, Abhijit and Esther Duflo. (2000). "Inequality And Growth: What Can The Data Say," Working Paper No. 00-09, M.I.T.

Bardhan, Pranap and Jeff Dayton-Johnson. (1999). "Inequality and Conservation on the Local Commons: A Theoretical Exercise," mimeo. University of California, Berkeley.

Bardhan, Pranap. (1999). "Irrigation and Cooperation: An Empirical Analysis of 48 Irrigation Communities in South India". *Economic Development and Cultural Change.*

Coleman, James. (1988). "Social Capital in the Creation of Human Capital". *American Journal of Sociology*. Vol. 94, Supplement S95-S120.

Dani, A. H. (1989). History of the Northern Areas of Pakistan, Islamabad: National Institute of Historical and Cultural Research.

Dayton-Johnson, Jeff. (2000a). "The Determinants of Collective Action on the Commons: A Model with Evidence from Mexico," *Journal of Development Economics*, 62.

Dayton-Johnson, Jeff. (2000b). "Choosing Rules to Govern the Commons: A Model with Evidence from Mexico," *Journal of Economic Behavior and Organization*, 42.

Deininger, Klaus and Pedro Olinto. (2000). "Asset Distribution, Inequality and Growth," *Policy Research Working Papers*, 2375, World Bank, Washington, D.C.

Easterly, William, and Ross Levine. (1997). "Africa's growth tragedy: policies and ethnic divisions," *Quarterly Journal of Economics*, 112.

Frank, Robert. (1993). “Social Capital and Economic Development,” Workshop on Social Capital and Economic Development, American Academy of Arts and Sciences, Cambridge July 1993.

Government of Pakistan. (1984). “1981 District Census Report of Baltistan,” Islamabad.

Government of Pakistan. (1998). “Population and Housing Census of the Northern Areas 1998,” Census Bulletin-12, Islamabad.

Hart, Oliver and Bengt Holmstrom. (1987). “The Theory of Contracts,” in T. Bewley, ed., Advances in Economic Theory, Fifth World Congress. Cambridge: Cambridge University Press.

Hirschman, Albert. (1967). Development projects observed, Washington: Brookings Institution.

Holmstrom, Bengt. (1982). “Moral Hazard in Teams,” 13 *Bell Journal of Economics* 324-40.

Isham, Jonathan, Deepa Narayan and Lant Pritchett (1996). “Does Participation Improve Performance? Establishing Causality with Subjective Data,” *World Bank Economic Review*, 9(2).

Khan, Akhtar Hameed. (1996). Orangi Pilot Project: Reminiscences and Reflections, Karachi: Oxford University Press.

Khan, Shoaib Sultan and Tariq Hussain. (1984). “Principles and Implementation for Small Farmer Development,” First Annual Review, Aga Khan Rural Support Programme.

Khwaja, Asim Ijaz. (1999). “Revisiting Rural Infrastructural Investments,” Aga Khan Rural Support Programme.

Lam, Wai Fung. (1998). Governing Irrigation Systems in Nepal: Institutions, Infrastructure and Collective Action, Oakland, California: ICS Press.

MacDonald, Kenneth Ian. (1989). “The Impact of Large Landslides on Human Settlements at Hopar, Karakoram Himalayas, Northern Pakistan,” *Annals of Glaciology,* 13, 185-9.

MacDonald, Kenneth Ian. (1994). “The Mediation of Risk: Ecology, Society and Authority in Askole, a Karakoram Mountain Agro-Pastoral Community,” Doctoral Thesis, University of Waterloo, Ontario, Canada.

Miguel, Edward. (1999). “Ethnic Diversity and School Funding in Kenya,” mimeo, Harvard University.

Narayan, Deepa. (1995). “The Contribution of People’s Participation: Evidence from 121 Rural Water Supply Projects,” *ESD Occasional Paper Series 1*.World Bank, Washington D.C.

Olson, Mancur. (1965). “The Logic of Collective Action: Public Goods and the Theory of Groups,” *Harvard Economic Studies* No. 124, Harvard University Press, Cambridge.

Ostrom, Elinor. (1990). Governing the Commons: The evolution of Institutions for Collective Action, New York: Cambridge University Press.

Parvez, Safdar and Ehsan-ul-Haq Jan. (1998). “Growth, Poverty and Inequality in the Programme Area,” working paper, Aga Khan Rural Support Program.

Putnam, Robert (with Robert Leonardi and Raffaela Nanetti). (1993). Making Democracy Work. Princeton: Princeton University Press.

Putnam, Robert. (1995). “Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America,” *Political Science and Politics*. December, 1995.

Stewart, Frances. (1978), Technology and underdevelopment, London : Macmillan.

Tang, Shui Yan. (1992). Institutions and Collective Action: Self-Governance in Irrigation, San Francisco : ICS Press.

Tendler, Judith (1993). New lessons from old projects: The workings of rural development in Northeast Brazil, A World Bank Operations Evaluation Study. Washington, D.C.: World Bank Operations Evaluation Department.

Tendler, Judith. (1997). Good government in the tropics, Johns Hopkins Studies in Development. Baltimore and London: Johns Hopkins University Press.

Uphoff, Norman. (1996). Learning from Gal Oya: Possibilities for Participatory Development and Post-Newtonian Social Science, London: London IT Publications.

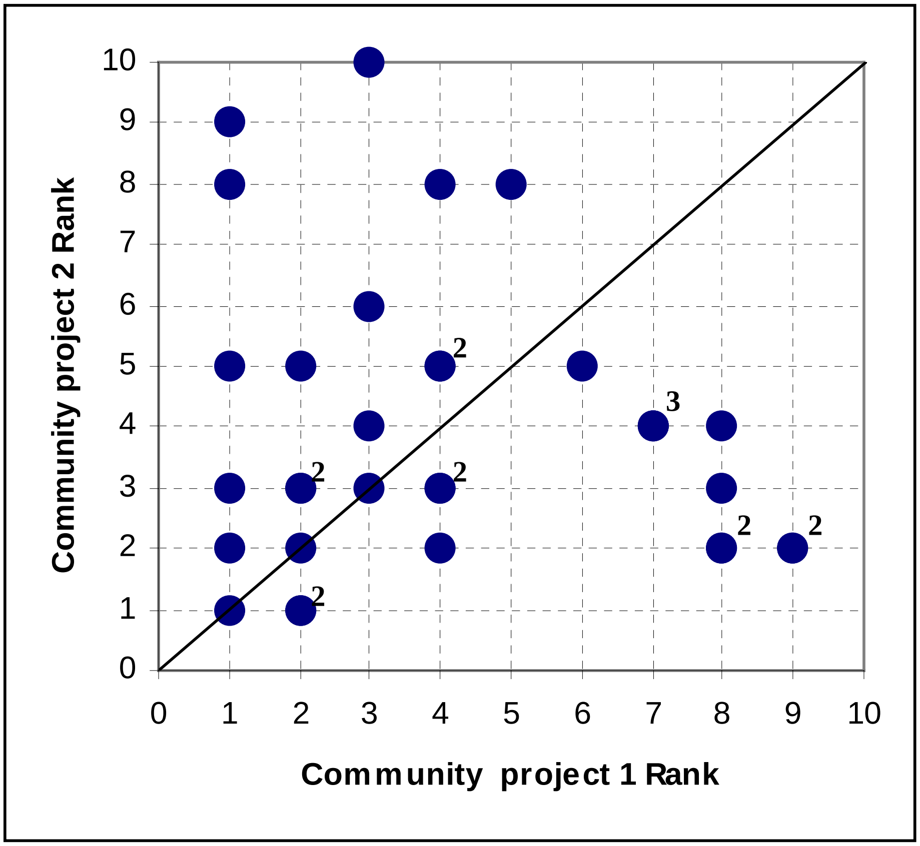
Wade, Robert. (1987). Village Republics: Economic Conditions for Collective Action in South India, Cambridge, U.K: Cambridge University Press.

Whiteman, P.T.S. (1985). “Mountain Oases: A Technical Report of Agricultural Studies in the Hunza, Ishkoman and Yasin Valleys of Gilgit District,” FAO/UNDP.

World Bank (1990). “The Aga Khan Rural Support Program in Pakistan: A Second Interim Evaluation,” World Bank Operations and Evaluation Department, Washington, D.C.

World Bank (1996). The World Bank Participation Sourcebook, Washington, D.C.: The World Bank.

Figure 1: Within-community project total score ranks



Project are ranked using the total score measure in Table 2 rounded to the nearest decile. Doing so simplifies the plot as only 10 ranks are possible. Moreover, this eliminates assigning a different rank to projects with very close total scores. Similar patterns hold if ranks are assigned using the full measure. The number of communities corresponding to a point (in case there is more than one such community) is indicated next to the point.

Figure 2: Map of Pakistan and Baltistan (inset)

Figure 3: Map of Baltistan with sampled communities indicated

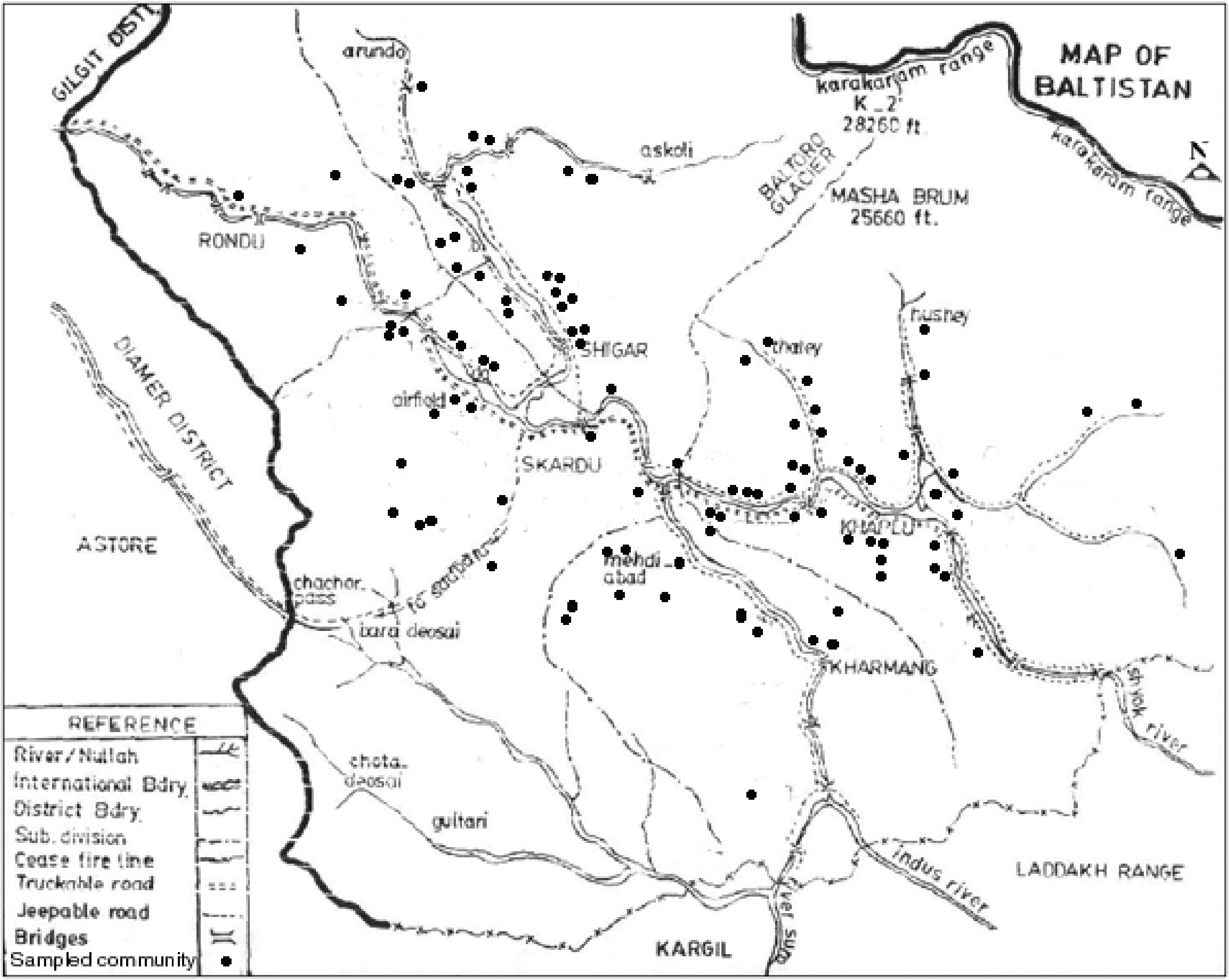
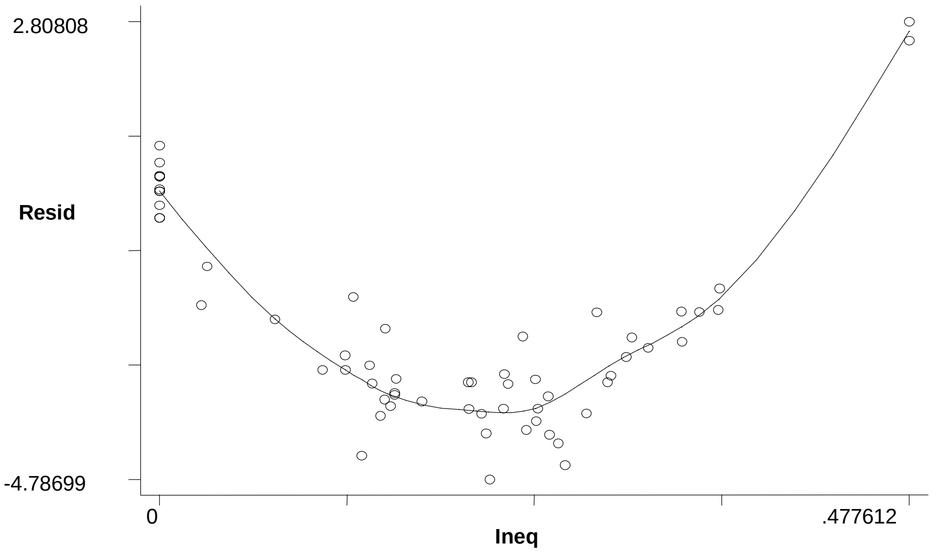
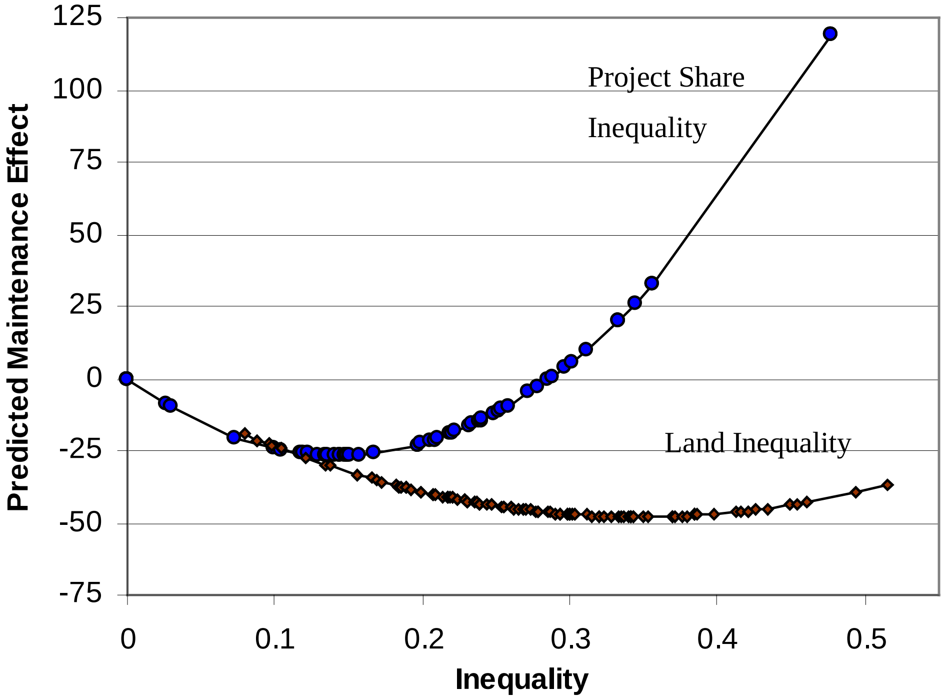


Figure 4: total score residuals (Resid) against Project Share Inequality (Ineq)



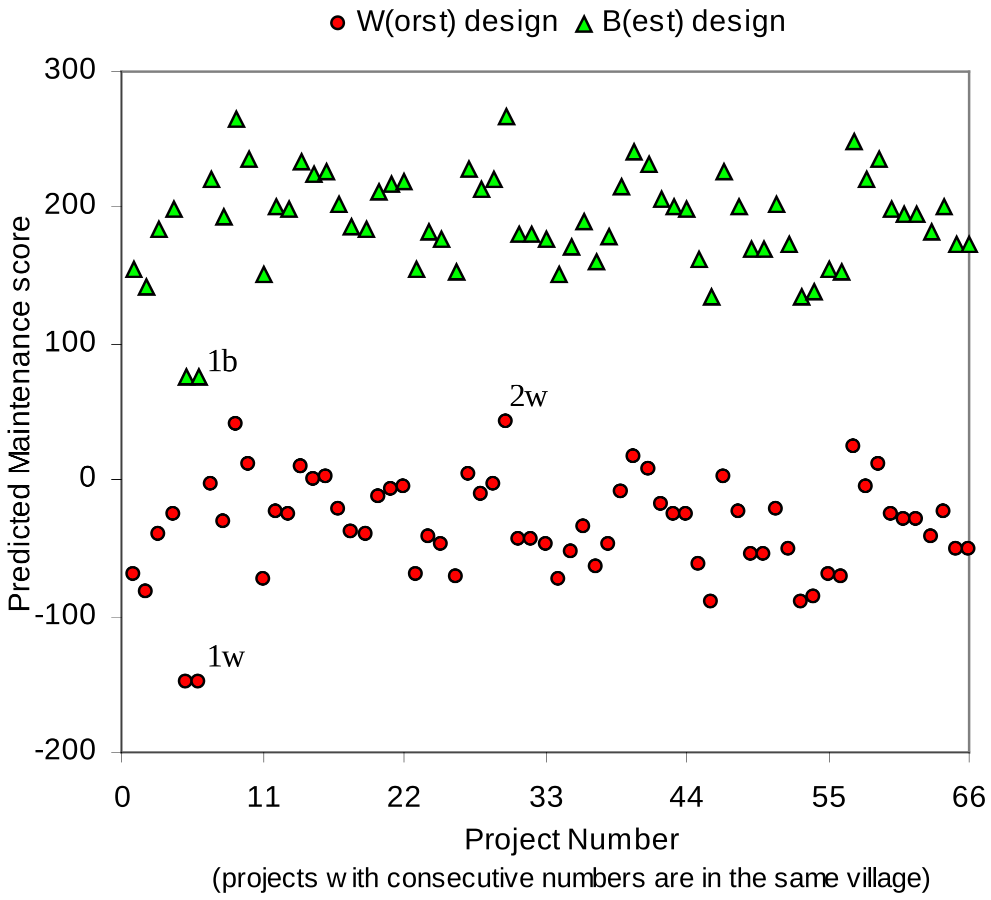
The residuals are calculated from a regression of project maintenance on project age, type and community dummy variables only. Excluding the two outlyers (highest inequality levels) does change the shape or fit of the plot.

Figure 5: Estimated magnitude comparisons – Land and Project Share Inequality



Predicted effects are calculated by estimating the marginal effect of the inequality measure after controlling for all other factors. For the land inequality the estimates used are from the regression in Table 5, and for project share inequality the estimates are from the regression in Column 1, Table 7. Excluding the high project share inequality outlyer does not significantly change the point estimates in the regression.

Figure 6: Predicted Maintenance for Best and Worst designed projects



The two maintenance scores for each project are predicted based on the estimates obtained in the community fixed effects regression reported in Table 7 (Column 1). The lower (higher) project score is obtained by setting project-design factors at their worst (best) within sample levels. Thus the best (worst) project score for project A in village 1 is obtained by predicting the score under the following values: project complexity index = 0 (3); community participation in non-technical decisions = 100 (0); community participation in technical decisions = 0 (100); project is a continuation (new) project; project is initiated by the NGO (Government); and project share inequality =0 (0.143). Note that the best value for project share inequality given the estimates is the maximum inequality value (1 in the sample). However, the best-case prediction chooses perfect equality since it is likely to be preferred for equity reasons. Doing so gives a lower estimate for the impact of the project-design factors.

Table 1: Sampled Projects by Project Type

1. Irrigation Channels	2. Protective Flood-Works	3. Pipe/ Siphon Irrigation	4. Lift Irrigation	5. MicroHydel Electricity	6. Link Roads	7. Boundary Walls
34	20	16	6	7	29	20

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Total Score	132	67.6	25.8	6.7	103.3
Physical score (0-110) [#]	132	74.8	20.5	0	110
Functional score (0-110)	132	71.1	35.4	0	110
Maintenance-work score (0-100)	132	57	28	10	100
Project Share Inequality	123	0.19	0.15	0	1
Project New? (1= new project)	132	0.83	.	0	1
External Organization (1=AKRSP, 0=LB&RD or Other)	132	0.77	.	0	1
External Organization (1=LB&RD, 0=AKRSP or Other)	132	0.17	.	0	1
Project complexity (0-3)	132	1.3	1.1	0	3
Project leader exists? (1=yes)	132	0.68	.	0	1
Leader Quality	132	0.69	0.39	0	1
Community (direct) participation: non-technical decisions	132	30	19	0	78
Community (total) participation: technical decisions	132	45	30	0	100
Project Age	132	8	4	0[*]	29
Project Benefit (Million Rs)	132	2.3	4.7	0	40
External Funds (000 Rs)	132	139.6	165.1	2.2	1400
Land Inequality	132	0.27	0.09	0.08	0.52
Social Heterogeneity	132	0.34	0.13	0	0.71
Community size (hh)	132	63	51	13	235
Travel Time (min) – to capital by jeep	132	166	81	10	360
Walk time (min) – to road on foot	132	10	28	0	180
Community cultivatable Land (kanals[$])	132	1403	1496	80	7000
Shopkeeper fraction	132	0.08	0.08	0	0.54
Skilled worker fraction	132	0.12	0.13	0	0.60
Basic education (Primary to higher secondary) fraction	132	1.17	0.88	0.03	4.6
Tertiary education (Graduate/post-graduate) fraction	132	0.08	0.10	0	0.45
Religious education fraction	132	0.07	0.09	0	0.67
Mean off-farm household income (Rs)	132	2019	1525	80	8000
Mean real estate value (000 Rs/kanal)	132	137	106	1	700
Local Wage (Rs/hour)	132	64	12	30	130
Households with mechanized assets (no)	132	2	4	0	30
Single Cropping zone? (1=yes)	132	0.23	.	0	1
Access to Electricity? (1=yes)	132	0.62	.	0	1
Access to Health facilities? (1=yes)	132	0.48	.	0	1
Access to Potable water? (1=yes)	132	0.48	.	0	1

[#] The index for physical and functional score ranges from 0-110 instead of 0-100 as the score is increased by 10 if the community has made substantial extensions/modifications to the project in an effort to better capture the community's performance. This increase does not affect the results.

[*] Two projects in the sample were completed recently (several months prior to the survey) and are assigned an age of 0. Project scores are not significantly higher for these projects (since they took a couple of years to complete, earlier parts of the project were damaged) and the results are not driven by them. They are retained to reduce small sample biases.

[$] There are 8 kanals in one acre (43,560 square feet)

Table 3. Project Score Correlations

	Physical score	Functional score	Maintenance-work score	Total score
Physical score	1.0000			
Functional score	0.7247	1.0000		
Maintenance-work score	0.7545	0.8057	1.0000	
Total score	0.8707	0.9421	0.9315	1.0000

Table 4. Participation levels (%) in Project Actions & Decisions – summary statistics

Action/ Decision	Obs	Mean	Std. Dev.
Non-Technical decisions (direct participation):			
Selecting project	132	80	29
Deciding level and distribution of community labor contribution in project construction	132	36	33
Deciding level and distribution of community non-labor (cash) contribution in project construction	132	24	30
Deciding wage to be paid for community labor used in project construction	132	36	35
Deciding on any compensation paid for non-labor community resources used in project construction (e.g. land given up)	119	13	25
Labor work for project construction	132	85	24
Monetary contribution for project construction	132	36	41
Deciding project usage/access rules (e.g. who gets to use the project when)	132	13	23
Deciding sanction measures for project misuse (e.g. amount and nature of fines levied)	132	14	21
Raising Internal (to community) funds for project construction and maintenance	132	9	19
Deciding on distribution of project benefits (e.g. allocation of water, electricity across households)	129	19	32
Deciding on maintenance system, policies and rules	132	20	29
Deciding on level and distribution of community monetary contribution in project maintenance	132	17	28
Deciding on level and distribution of community labor work towards project maintenance	132	28	34
Deciding on nature, level and extent of any sanctions imposed for not participating in project maintenance	132	22	29
Overall participation for non-technical decisions	132	30	19
Technical decisions (direct & indirect participation):			
Deciding project site	132	44	42
Deciding project scale (length, capacity)	132	43	40
Deciding design of project	132	34	40
Deciding time-frame for project construction	132	35	38
Raising external (to community) funds for project construction and maintenance	132	69	38
Overall participation for technical decisions	132	45	30

Table 5. Determinants of Maintenance

Variables	(1) OLS	Variables	(1-cont) OLS
Community characteristics:		**Physical capital variables:**	
Land Inequality	-275.4**	Mean off-farm hh Income	-.0012
	(117)		(.0021)
Land Inequality Squared	395.7**	Mean real estate value (000)	-.044**
	(194)		(.022)
Social Heterogeneity	-55.1***	Mean community wage	.127
	(18)		(.160)
Community size	-.020	Mechanical asset household fraction	2.05***
	(.062)		(0.49)
Community land	2e-04	Access to Electricity?	5.13
	(18e-04)		(4.38)
Single cropping zone?	-8.79	Access to Health facility?	-1.21
	(5.58)		(4.50)
Walk Time	-.046	Access to Potable Water?	3.22
	(.075)		(4.37)
Travel Time	-.022		
	(.040)		
Human capital variables:		**Project variables:**	
Shopkeeper fraction	-71.9***	Project New?	-20.5***
	(27.2)		(6.05)
Skilled worker fraction	32.5**	External organization (=Government?)	-8.96
	(15.0)		(7.58)
Basic Education fraction	-3.37	Project Leader exists?	11.3**
	(3.72)		(5.7)
Tertiary Education fraction	36.0	External Funds (000,000)	6.96
	(26.3)		(11.3)
Religious Education fraction	-36.8	Project Complexity	-4.20
	(24.1)		(2.77)
High school?	20.6***	Non-technical decisions participation	35.5***
	(6.4)		(15.4)
		Technical decisions participation	-18
			(12.6)
		Controls	Pj age, type
		Adj R^2	.35
		Prob>F	.00
		N	132

Huber-White robust standard errors in parentheses
Disturbance terms clustered at the village level
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Table 6. Effect of Project Leadership on Maintenance

OLS and Instrumental Variable (IV-2SLS)

Variables	(1) 1st stage OLS	(2) 2nd stage IV- 2SLS	(3) OLS	(4) 1st stage OLS	(5) 2nd stage IV- 2SLS
Project Leader exists?	Dependent variable	32.64** (15.70)	36.45*** (13.64)		25.11* (15.04)
Leader Quality				Dependent variable	42.03** (16.94)
Hereditary family 25-50 healthy male?	0.30* (0.18)				
Hereditary family absence (1-3)	-.32*** (.12)				
Hereditary family average age	-.015** (.006)				
Hereditary family 25-50 educated, present male				0.10*** (0.04)	
Hereditary family non-farm?				-0.20*** (0.08)	
Ideal leaders in community? (1-4)				0.21*** (0.08)	
Project Leader attributes:					
Educated?			-3.15 (6.19)		
Age			-.52** (.21)		
Non-farm occupation?			-10.4** (5.95)		
Land holding			-.001 (.056)		
Present throughout year?			7.63 (9.22)		
Trained?			5.05 (5.6)		
From hereditary leader group?			-10.4* (5.94)		
Controls		Community Characteristics, Physical & Human Capital and Project variables	Community Characteristics, Physical & Human Capital and Project variables		Community Characteristics, Physical & Human Capital and Project variables
Adj R^2	.09	.21	.34	.07	.43
Prob>F	.00	.00	.00	.00	.00
N	132	132	130	132	132

Huber-White robust standard errors in parentheses
Disturbance terms clustered at the village level
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Table 7. Project-specific Determinants of Maintenance

Community Fixed Effects

Variables	(1) FE	(2) FE	(3) FE
Project Complexity	-12.76*** (3.85)	-15.19*** (3.04)	-15.44*** (3.92)
Project Share Inequality	-373.3*** (67.7)	-402.7*** (86)	-422*** (69.2)
Project Share Inequality squared	1304*** (225)	1391*** (267)	1381*** (211)
Non-technical decisions participation	55.43* (28.29)		50.87* (24.24)
Technical decisions participation	-38.49* (18.56)		-34* (16.68)
External organization (=Government?)	-23.63*** (7.95)	-18*** (6.07)	-18.18** (8.03)
Project New?	-41.92*** (13.67)	-40.55*** (11)	-46.77*** (15.06)
Project Leader?			13.36 (8.42)
Controls	Community Fixed Effects, Project Age and type	Community Fixed Effects, Project Age and type	Community Fixed Effects, Project Age and type
Adj R^2	.71	.63	.73
Prob>F	.00	.00	.00
N	64	64	64

Column 1 presents the primary regression. Column 2 checks to see whether the results remain similar once the potentially endogenous (Halo effects) participation measure is excluded. Column 3 checks to see whether the external agency effect remains once leadership presence (endogenous) and participation are both controlled for.

Huber-White robust standard errors in parentheses
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Table 8. Project-specific Determinant Interactions

IV-2SLS and Fixed Effects

Variables	(1) 1st stage OLS	(2) IV-2SLS FE	(3) FE	(4) FE	(5) FE
Complexity*Leader exists?	Dependent variable	36.18**			
		(15.44)			
Complexity*Hereditary family 25-50 healthy male?	0.29				
	(0.20)				
Complexity*Hereditary family absence (1-3)	-.27				
	(.19)				
Complexity*Hereditary family average age	-.018*				
	(.011)				
Complexity		-50.87**	0.37		-24.43
		(17.72)	(7.93)		(17.83)
External organization (=Government?)			8.11	17.52	
			(17.19)	(19.52)	
Project New?				-10.32	-53.81**
				(19.98)	(23.62)
External organization*New?				-48.50**	
				(21.48)	
Complexity*New?					13.21
					(20.30)
Complexity*External organization			-20.19**		
			(8.91)		
Controls		Community FEs, Project Age, type, History, External organization, Return Inequality, Participation	Community FEs, Project Age, type, History, Return Inequality, Participation	Community FEs, Project Age, type, Complexity, Return Inequality, Participation	Community FEs, Project Age, type, External organization, Return Inequality, Participation
Adj R^2	.36	.70	.79	.80	.70
Prob>F	.00	.00	.00	.00	.00
N	132	64	64	64	64

Huber-White robust standard errors in parentheses
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Table 9. Participation assumptions and Halo effects

Robustness Checks (OLS)

Dependent Variable	(1) External organization perceived as main player?	(2) External organization perceived as main player?	(3) External organization perceived as main player?	(4) External organization perceived as main player?	(5) External organization perceived as main player?	(6) Individual physical score – average score	(7) Individual functional score – average score
Technical Participation:							
Deciding project site	-.42*** (.06)						
Deciding project scale (length, capacity)		-.34*** (.07)					
Deciding design of project			-.25*** (.07)				
Deciding time-frame for project construction				-.13* (.07)			
Raising external (to community) funds for project construction and maintenance					.04 (.23)		
Individual participation – average participation						-.37 (.41)	-.27 (.53)
Controls							
Adj R^2	0.22	0.14	0.07	0.02	.00	.00	.00
Prob>F	0.00	0.00	0.00	0.08	.84	0.32	.55
N	132	132	132	132	132	648	652

Huber-White robust standard errors in parentheses
Disturbance terms clustered at the village level
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Columns indicate independent variables and rows dependent variables. In Columns (1)-(5) the independent variable is a binary indicator of whether the community identified that the external organization as the main player in the given decision. Columns (6)-(7) check for Halo effects

Table 10. External organization effect – Robustness checks

Variables	(1) OLS Total Score	(2) OLS Functional Score
External organization (=Government?)	-25.53***	-25.99*
	(8.90)	(14.98)
Project Construction quality (1=good)	2.18	
	(9.62)	
External Funds (000,000)	-6.07	
	(15.3)	
Physical Score		0.42
		(0.35)
Controls	Community FEs, Project Age, type, History, Complexity, Return Inequality, Participation	Community FEs, Project Age, type, History, Complexity, Return Inequality, Participation
Adj R^2	.67	.65
Prob>F/chi^2	.00	.00
N	64	64

Huber-White robust standard errors in parentheses
***Significantly different from zero at 1%
**Significantly different from zero at 5%
* Significantly different from zero at 10%

Table 11. NGO versus local government – by project complexity

	% of NGO projects	% of local government projects
Projects that require relatively more cash as opposed to non-cash maintenance contributions	47	35
Projects that the community has had no prior experience in	48	35
Projects for which spare parts are not easy to obtain	65	43
Projects that require relatively more skilled labor spare parts rather than unskilled labor maintenance work	47	26

Theory Appendix

Assume N=2 and $r_1 \geq r_2$. Restricting to two households simplifies the analysis considerably. In particular, project return inequality is determined by the ratio of project returns, $\frac{r_1}{r_2}$.

Claim 1 *(a) For a standard community project, maintenance initially worsens as project return inequality increases from perfect equality. (b) However, the trend is reversed at higher inequality levels, and further increases in inequality improve maintenance.*

Proof. (a) For a standard community project at low inequality levels ($r_1 \approx r_2$), neither household can afford to employ indirect labor i.e. $m_1^* = m_2^* = 0$. Each household's optimal indirect labor choice is given by:

$$l_i^* \in \arg\max_{l_i} \left(\left\{ \frac{r_i}{r_1 + r_2} \right\} \cdot f[(1-\alpha)(l_1 + l_2)] - C_i(l_i) \right)$$

Using the implicit function theorem for a change in r_1:

$$\begin{pmatrix} (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)\frac{\partial^2 f}{\partial^2 l_1} - \frac{\partial^2 C_1}{\partial^2 l_1} & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)\frac{\partial^2 f}{\partial l_1 \partial l_2} \\ (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)\frac{\partial^2 f}{\partial l_2 \partial l_1} & (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)\frac{\partial^2 f}{\partial^2 l_2} - \frac{\partial^2 C_2}{\partial^2 l_2} \end{pmatrix} \begin{pmatrix} \frac{\partial l_1^*}{\partial r_1} \\ \frac{\partial l_2^*}{\partial r_1} \end{pmatrix}$$

$$= -\frac{r_2}{r_1 + r_2}(1-\alpha) \begin{pmatrix} \frac{\partial f}{\partial l_1} \\ -\frac{\partial f}{\partial l_2} \end{pmatrix}$$

The above expression can be simplified further by recognizing that $f(.)$, the level of benefits/maintenance of the project, is a function of aggregate labor. This implies that $\frac{\partial^2 f}{\partial^2 l_1} = \frac{\partial^2 f}{\partial^2 l_2} = \frac{\partial^2 f}{\partial l_1 \partial l_2} = \frac{\partial^2 f}{\partial l_2 \partial l_1} = f''$ and $\frac{\partial f}{\partial l_1} = \frac{\partial f}{\partial l_2} = f'$

Solving the above gives:

$$\frac{\partial l_1^*}{\partial r_1} = \frac{(1-\alpha) f' r_2}{r_1 + r_2} \left[\frac{\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f''}{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f'' \left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2} \right)} \right]$$

$$\frac{\partial l_2^*}{\partial r_1} = -\frac{(1-\alpha) f' r_2}{r_1 + r_2} \left[\frac{\frac{\partial^2 C_1}{\partial^2 l_1} - (1-\alpha)^2 f''}{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f'' \left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2} \right)} \right]$$

By assumption: $f' > 0$, $f'' < 0$ and $\frac{\partial^2 C_1}{\partial^2 l_1} > 0$, $\frac{\partial^2 C_2}{\partial^2 l_2} > 0$

This implies that $\frac{\partial l_1^*}{\partial r_1} > 0$ and $\frac{\partial l_2^*}{\partial r_1} < 0$. Moreover $r_1 = r_2 \Rightarrow l_1^* = l_2^*$. Therefore at $r_1 > r_2$, $l_1^* > l_2^*$

Let $l_{total}^* = l_1^* + l_2^*$. using the above expression and simplifying gives:

$$\frac{\partial l_{total}^*}{\partial r_1} = \frac{(1-\alpha) f' r_2}{r_1 + r_2} \left[\frac{\frac{\partial^2 C_2}{\partial^2 l_2} - \frac{\partial^2 C_1}{\partial^2 l_1}}{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f'' \left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2} \right)} \right]$$

By assumption: $\frac{\partial^3 C_1}{\partial^3 l_1} > 0, \frac{\partial^3 C_2}{\partial^3 l_2} > 0$. From above, at $r_1 > r_2$, $l_1^* > l_2^* \implies \frac{\partial^2 C_1}{\partial^2 l_1}|_{l_1^*} > \frac{\partial^2 C_2}{\partial^2 l_2}|_{l_2^*}$ and therefore $\frac{\partial l_{total}^*}{\partial r_1} < 0$ Since $\frac{\partial f(.)}{\partial l_{total}^*} > 0$ and an increase in r_1 corresponds to increasing inequality, this proves part (a) of the claim. i.e. project maintenance falls as inequality rises.

(b) By assumption, for a standard community project at high inequality levels ($r_1 \gg r_2$), household 1 can afford to employ indirect labor while household 2 cannot i.e. $m_1^* > 0, m_2^* = 0$.

Household 1's optimal choice is:

$$l_1^*, m_1^* \in \arg\max_{l_1,m_1} \left(\left\{ \frac{r_1}{r_1+r_2} \right\} \cdot f[(1-\alpha)(l_1+m_1+l_2)] - C_1(l_1) - M_0 - wm_1 \right)$$

Household 2's optimal choice is:

$$l_2^* \in \arg\max_{l_2} \left(\left\{ \frac{r_2}{r_1+r_2} \right\} \cdot f[(1-\alpha)(l_1+m_1+l_2)] - C_2(l_2) \right)$$

Using the implicit function theorem for a change in r_1 and the fact that $\frac{\partial^2 f}{\partial^2 l_1} = \frac{\partial^2 f}{\partial^2 m_1} = \frac{\partial^2 f}{\partial^2 l_2} = \frac{\partial^2 f}{\partial l_1 \partial l_2} = \frac{\partial^2 f}{\partial l_1 \partial m_1} = \frac{\partial^2 f}{\partial m_1 \partial l_2} = \frac{\partial^2 f}{\partial l_2 \partial l_1} = f''$ and $\frac{\partial f}{\partial l_1} = \frac{\partial f}{\partial m_1} = \frac{\partial f}{\partial l_2} = f'$ gives:

$$\begin{pmatrix} (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' - \frac{\partial^2 C_1}{\partial^2 l_1} & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' \\ (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)f'' \\ (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)f'' & (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)f'' - \frac{\partial^2 C_2}{\partial^2 l_2} & (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)f'' \end{pmatrix} \begin{pmatrix} \frac{\partial l_1^*}{\partial r_1} \\ \frac{\partial m_1^*}{\partial r_1} \\ \frac{\partial l_2^*}{\partial r_1} \end{pmatrix}$$

$$= -\frac{f' r_2}{r_1+r_2}(1-\alpha) \begin{pmatrix} 1 \\ 1 \\ -1 \end{pmatrix}$$

Solving the above: $\frac{\partial l_1^*}{\partial r_1} = 0$, $\frac{\partial m_1^*}{\partial r_1} = \frac{f' r_2}{r_1+r_2} \left[\frac{(1-\alpha)^2 f'' - \frac{\partial^2 C_2}{\partial^2 l_2}}{(1-\alpha) f'' \frac{\partial^2 C_2}{\partial^2 l_2} \left(\frac{r_1}{r_1+r_2} \right)} \right]$ and $\frac{\partial l_2^*}{\partial r_1} = -\frac{f' r_2}{r_1+r_2} \left[\frac{1-\alpha}{\frac{\partial^2 C_2}{\partial^2 l_2} \left(\frac{r_1}{r_1+r_2} \right)} \right]$

Let $l_{total}^* = l_1^* + m_1^* + l_2^*$. using the above expressions and simplifying gives:

$$\frac{\partial l_{total}^*}{\partial r_1} = -\frac{f' r_2}{(1-\alpha) f'' r_1}$$

By assumption: $f' > 0$, $f'' < 0$ and this implies that $\frac{\partial l_{total}^*}{\partial r_1} > 0$

Since $\frac{\partial f(.)}{\partial l_{total}^*} > 0$ and an increase in r_1 corresponds to increasing inequality, this proves part (b) of the claim. i.e. project maintenance increases as inequality rises. ■

Claim 2 *(a)More complex projects - those that require greater capital inputs and lack prior community experience - have lower maintenance, regardless of the community's characteristics. (b) Projects that lack good quality leaders also have lower maintenance, although there is an ambiguous effect of leader presence. (c) The leader effects are larger for more complex projects.*

Proof. (a)For simplicity, consider the case where $m_1^* = m_2^* = 0$. As before, each household's optimal indirect labor choice is given by:

$$l_i^* \in \arg\max_{l_i} \left(\left\{ \frac{r_i}{r_1+r_2} \right\} \cdot f[(1-\alpha)(l_1+l_2)] - C_i(l_i) \right)$$

Using the implicit function theorem for a change in α :

$$\begin{pmatrix} (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)\frac{\partial^2 f}{\partial^2 l_1} - \frac{\partial^2 C_1}{\partial^2 l_1} & (1-\alpha)^2\left(\frac{r_1}{r_1+r_2}\right)\frac{\partial^2 f}{\partial l_1 \partial l_2} \\ (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)\frac{\partial^2 f}{\partial l_2 \partial l_1} & (1-\alpha)^2\left(\frac{r_2}{r_1+r_2}\right)\frac{\partial^2 f}{\partial^2 l_2} - \frac{\partial^2 C_2}{\partial^2 l_2} \end{pmatrix} \begin{pmatrix} \frac{\partial l_1^*}{\partial \alpha} \\ \frac{\partial l_2^*}{\partial \alpha} \end{pmatrix}$$

$$= \left(f' + f''(1-\alpha) l_{total}^*\right) \begin{pmatrix} r_1 \\ r_2 \end{pmatrix}$$

Solving and simplifying gives:

$$\frac{\partial l_{total}^*}{\partial \alpha} = -\left[\frac{\{f' + f''(1-\alpha)l_{total}^*\}\left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2}\right)}{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f''\left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2}\right)}\right]$$

The above expression is negative iff $f' > f''(1-\alpha)l_{total}^*$ which is guaranteed to hold if the function is multiplicatively separable in α and l_{total}^*. The proof of part (a) holds even without assuming this condition i.e. total maintenance labor input provided by the households may increase, as α increases. However, this increase will always be more than compensated for by the fall in maintenance due to the direct effect of an increase in α - a decrease in the productivity of labor. This argument is illustrated below:

Since maintenance is increasing in $(1-\alpha)l_{total}^*$, the total effect on maintenance of a change in α is given by: $-l_{total}^* + (1-\alpha)\frac{\partial l_{total}^*}{\partial r_1}$. Substituting the above expression and simplifying gives:

$$\frac{\partial(1-\alpha)l_{total}^*}{\partial \alpha} = -l_{total}^*\left[1 - \frac{1}{1-k}\right] - \frac{f'\left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2}\right)}{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2} - (1-\alpha)^2 f''\left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2}\right)}$$

where $k = \frac{\frac{\partial^2 C_1}{\partial^2 l_1}\frac{\partial^2 C_2}{\partial^2 l_2}}{f''\left(\frac{\partial^2 C_1}{\partial^2 l_1}\frac{r_2}{r_1+r_2} + \frac{\partial^2 C_2}{\partial^2 l_2}\frac{r_1}{r_1+r_2}\right)}$

By assumption: $f' > 0$, $f'' < 0$ and $\frac{\partial^2 C_1}{\partial^2 l_1} > 0$, $\frac{\partial^2 C_2}{\partial^2 l_2} > 0$ which implies that $k < 0$ and the second term in R.H.S. of the equation is also negative. Together this implies that $\frac{\partial(1-\alpha)l_{total}^*}{\partial \alpha} < 0$ and hence project maintenance is decreasing in α. Since α is an increasing function of project complexity, this proves part (a) i.e. maintenance falls as project complexity increases. The proof for the remaining case ($m_i^* \neq 0$) is similar.

(b) As shown in part (a) $\frac{\partial(1-\alpha)l_{total}^*}{\partial \alpha} < 0$. Since $\frac{\partial \alpha}{\partial(leader-quality)} < 0$, this implies maintenance is lower for projects that lack good quality leaders. However, $\frac{\partial \alpha}{\partial(leader-presence)} is > \text{ or } < 0$, and so leader presence has an ambiguous effect.

(c) By assummtion $\left|\frac{\partial \alpha}{\partial leadership}\right| = h(.)$ where $h(.)$ is increasing in project complexity. From part (a), $\frac{\partial f(.)}{\partial \alpha} < 0$. Since the change in α arising due to the presence of a project leader is increasing in project complexity, this implies the leader effect on maintenance is larger for more complex projects. ■

Claim 3 *(a) Increased community participation in non-technical project decisions taken before, during or after project construction, improves project maintenance. (b) However, greater community participation in technical decisions worsens project maintenance.*

Proof. (a) In deciding optimal information investment levels in decision i,the community's benefit is:

$$\pi B(\delta_i(L,T)) + (1-\pi)V(L)$$

while the external organization's benefit is:

$$\widetilde{\pi} B(\delta_i(L,T)) + (1-\widetilde{\pi})Q(T)$$

where L = local information investment level and T = technical information investment level

Since $B(.)$, $V(.)$ and $Q(.)$ are increasing in informational investments(and these investments are costly), this implies the following relationship between optimal investment levels chosen by the two agents: $L^*_{community} > L^* > L^*_{ext-org}$ and $T^*_{community} < T^* < T^*_{ext-org}$., where L^* and T^* are the informational investments, if the benefit is given only by $B(.)$.

Since higher community participation, P_i^C increases the weight on the community choice this implies that $\frac{\partial L^*_{final}}{\partial P_i^C} > 0$ and $\frac{\partial T^*_{final}}{\partial P_i^C} < 0$, For non-technical decisions $\frac{\partial \delta_i}{\partial L} > \frac{\partial \delta_i}{\partial T}$, therefore this implies $\frac{\partial \delta_i}{\partial P_i^C} > 0$. Letting $\delta_i = 1 - \alpha$, the proof in Claim 2, part (a) shows that $\frac{\partial f(.)}{\partial \delta_i} > 0$ and hence proves the result $\frac{\partial f(.)}{\partial P_i^C} > 0$ for non-technical decisions.

(b) The proof is similar to that of part (a). For technical decisions $\frac{\partial \delta_i}{\partial L} < \frac{\partial \delta_i}{\partial T} \implies \frac{\partial \delta_i}{\partial P_i^C} < 0 \implies \frac{\partial f(.)}{\partial P_i^C} < 0$ i.e. increased community participation in technical decisions worsens maintenance. ■

Derivation of Equation 2

Let the project maintenance/benefit function, $f(.) = \log(.)$. The equilibrium maintenance level is given by:

$$M_{ip} = \log(1 - \alpha_{ip}) \prod_{j}^{M} \delta_{ip_j} l^*_{total_{ip}}$$

where $l^*_{total_{ip}}$ is the equilibrium aggregate direct and indirect labor input provided by all households in the p^{th} project in the i^{th} community. Household i's optimal choice:

$$l_i^*, m_i^* \in \arg\max_{l_i, m_i} \left(\left\{ \frac{r_i}{r_1 + r_2} \right\} \cdot \log\left[(1 - \alpha) \prod_{j}^{M} \delta_j (l_1 + m_1 + l_2 + m_2)\right] - C_i(l_i) - M_0 - w m_i \right)$$

is equivalent to[1]:

$$l_i^*, m_i^* \in \arg\max_{l_i, m_i} \left(\left\{ \frac{r_i}{r_1 + r_2} \right\} \cdot \log(l_1 + m_1 + l_2 + m_2) - C_i(l_i) - M_0 - w m_i \right)$$

Solving for the optimal choices gives $l^*_{total} = h\left(\frac{r_1}{r_1 + r_2}\right)$ since the above expression is independent of both α and the $\delta'_j s$.

In addition, $\delta_{ip_j} = d\ (P^C_{ip_j})$. Plugging into the expression for M_{ip} above, gives equation 2:

$$M_{ip} = A_{ip}\beta_1 + Pc_{ip}\beta_2 + I_{ip}\beta_3 + \varepsilon_{ip} \tag{2}$$

where $A_{ip} = \log(1 - \alpha_{ip})$ and $Pc_{ip} = (\log d(P^C_{ip_1}), ..., \log d(P^C_{ip_M}))$ and $I_{ip} = \log h(\frac{r_1}{r_1 + r_2})_{ip}$

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[1] The two are equivalent provided that changes in a/δ_j do not affect the participation constraint i.e. households still think it worthwhile to exert non-zero effort.