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The Free Rider Problem in Community-Based Rural Water Supply: A Game Theoretic Analysis

by

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The Free Rider Problem in Community-Based Rural Water Supply: A Game Theoretic Analysis

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Abstract

Community-based water supply projects in rural South Africa have frequently proved unsustainable, with many communities unable to raise sufficient funds to meet operation and maintenance costs. A key obstacle to cost recovery (and the focus of this paper) is the free rider problem. As rural water services are frequently supplied as a public good, the link between paying for water and receiving it is not as straightforward as it is for private goods, and beneficiaries may have a material incentive to 'free ride' on the good's production. Using a simple game-theoretic model, we identify and discuss the value of social sanctioning in deterring free riding. We conclude that social norms that generate costly punishment, such as norms of fairness may be necessary (but not sufficient) to deter free riding. We emphasise the importance of community mobilisation, social intermediation and institution building in overcoming the free rider problem.

1. Introduction

Basic water supply projects in rural villages are typically operated and maintained by the community, rather than the state. In this paper, we argue that projects create a social dilemma for beneficiary communities. Rural water supply is typically provided as a non-excludable public good, and economic theory suggests that projects may therefore face a Prisoner's dilemma or free rider problem (Olson, 1965; Hardin, 1982). Where communities are required to meet operations and maintenance costs collectively, there is an incentive for individuals to 'free ride' – withholding contribution and enjoying the water anyway. Because projects are expected to be sustainable without ongoing state support, the onus is on communities to deter free riding. In this paper, we examine the potential of informal sanctioning of non-contributors, by modeling a case where contributors break social ties with free riders. Sanctioning others in the community can be socially costly, and may require *social norms*, such as fairness, to be credible (Ostrom, 2000; Fehr and Gachter, 2000). When norms are strong enough to ensure that punishment is credible, our model suggests that players will display 'conditionally cooperative' behaviour, contributing only when convinced that a sufficient proportion of the community is prepared to do likewise. When demonstrated willingness to cooperate within the community has reached a critical mass, an equilibrium involving 100% cooperation is reached. This conclusion supports a common policy of NGOs (including South Africa's Mvula Trust), which prescribes that community contributions attain a funding threshold before the project begins.

2. Community water supply

Basic water supply projects in rural villages are typically operated and maintained by the community, rather than the state. The community-based approach is motivated by the need to ensure project *sustainability*. In South Africa, rural villages are geographically isolated and linked by poor roads, and it is difficult for local government officials and engineers to attend to project problems on time (Moat *et al*, 2003). Internationally, projects that are dependent upon ongoing state input have generally failed (UNDP, 1998). The community-based approach is also justified as a means to promote the development of skills (human capital) and civic organisation (social capital) (Hemson *et al*, 2004), to empower women (Hemson, 2002). The approach is also touted as being cost-effective – requiring communities to meet operations and maintenance costs frees state resources for investment in previously un-served communities (Still, 2001).

Community-based projects in South Africa have frequently failed – despite notable successes, many communities failed to recover the costs of operations and maintenance, with non-payment cited as a key problem (e.g. Dreyer, 1998; Hagg and Emmet, 2003). In this paper, we suggest *one* potential cause of project failure – the free rider problem.

3. The Free Rider Problem

If water projects are to be sustainable, the ongoing costs of operating and maintaining them need to be met. Typical operations and maintenance costs of community water projects include the purchases of diesel or payment of electricity bills to operate the pump, purchases of spare parts for repair and maintenance, stationery for book-keeping, transport costs, telephone bills and compensation for care-takers, book-keepers and other committee members (Cain *et al*, 2000; Still *et al*, 2003).

These costs are typically met by levying a monthly flat-rate tariff to households. The cost of these tariffs vary, but are typically between R2,50 and R10 per month. The graphical presentation of tariff rates below uses data from a study by Still *et al* (2003).

As shown in figure 2, community payment rates were frequently (though not always) low. This implied that total receipts were seldom sufficient to recover budgeted income (Still *et al*, 2003).

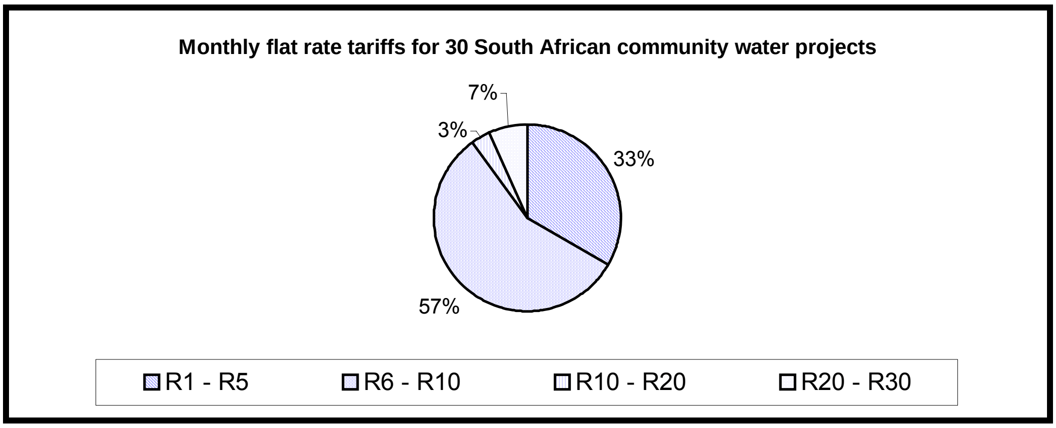

Figure 1

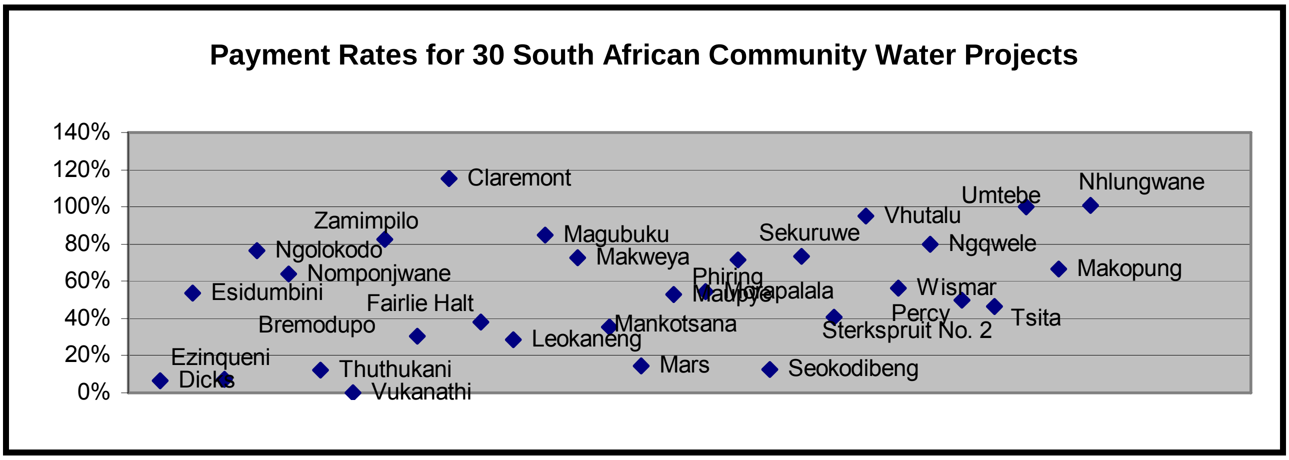

Figure 2

While there are many feasible motivations for withholding payment, we focus on *free riding* as one of the underlying causes of non-contribution. Water supply in rural areas is typically provided as a public good – its defining feature being its *non-excludability*[1]. Services are typically provided through communal standpipes, and it is thus difficult to exclude non-payers from consuming the good. Non-payment for services by South African households was a frequent occurrence. Non-payers sometimes justified their choice by arguing that 'water is from God', or that 'the RDP is for free' (Dreyer, 1998).

One method for solving the free rider problem is by ensuring that it is excludable. In the case of community water supply, this has sometimes been achieved. Certain projects accomplished this by installing prepaid meters at communal standpipes (LIMA, 2000). The Nhlungwane project in Kwazulu Natal employed *nompompis* – women in the community who kept keys for standpipes, which were opened at specific times of day to those who had paid (Mvula, 2004). Excludability seems to be an exception, rather than a rule. Even where exclusion at tap-stands is carried out, it is nevertheless possible to 'free ride' by making

[1] The characteristic of non-rivalry is often cited as a defining one for a public good. Community water supply is not strictly non-rival – one person's consumption does impair the amount of water available for others to enjoy. Nevertheless, the characteristic of non-rivalry does not present the free rider problem from occurring (Hardin, 1982).

unauthorised connections to the supply. This has been widely reported in South African schemes (Wellman, 1999). The model in this paper assumes that projects are non-excludable.

4. A Game Theoretic Analysis

The social dilemma of public goods provision can be expressed most simply as a one-shot *n*-person Prisoner's dilemma (PD), with binary contributions and a linear production function. Drawing from a discussion by Taylor and Ward (1982), a public goods scenario takes the form of a PD when the following hold:

1. No player can *profitably* provide any of the good by herself.
2. If all players contribute, each player's welfare is improved.
3. Each player does best for herself by free riding while the other(s) contributes.

A simple one-shot PD model of a community water project is developed as follows:

Assume that a community has *n* members. Government installs a water project in the community, and each member is asked to contribute a flat rate monthly tariff. Each contribution increases the funds available *in that month* to buy diesel for the pump. The project's value to any player in a specific month is an increasing function of that month's contribution level. When the number of contributors is zero, the project does not provide any utility. When total contributions are low, there will only be enough funds to allow the pump to operate for a short period of time, so that the project's value is low. When total contributions approach *n* (100% payment), the project's value to beneficiaries is high. The project's value is thus an increasing function of the number of contributions. For simplicity, we assume that the project's production function, which maps the value of the project as a function of the number of contributions, is a linear one. Each contribution increases the project's value to each player by a fixed amount *V*, as shown below. Contribution costs *C*. The net benefit to any individual from contribution is thus $V – C$ (which implies a net cost if $V – C < 0$).

We assume that the water project is the most convenient source of water for the community. As long as the number of contributions exceeds zero and *some* water is pumped to the standpipes, players will prefer to access the project's water, rather than use traditional water sources. We thus ignore the latter possibility.

The public goods game can be represented most simply as a one-period 2-player game. The payoffs of player 1 and 2 are listed first and second respectively.

The game becomes a Prisoner's dilemma when conditions 1) to 3) hold, i.e.:

1) $V – C < 0$ (The cost of contributing outweighs the associated benefit. A player therefore cannot *profitably* provide any of the public good by himself)[2] .

[2] This is Olson's (1965) definition for a latent group.

2) $2V - C > 0$. (If both contribute, each player's welfare is improved).

3) $V > 2V - C$ (Each player does even better for himself by free riding while the other contributes).

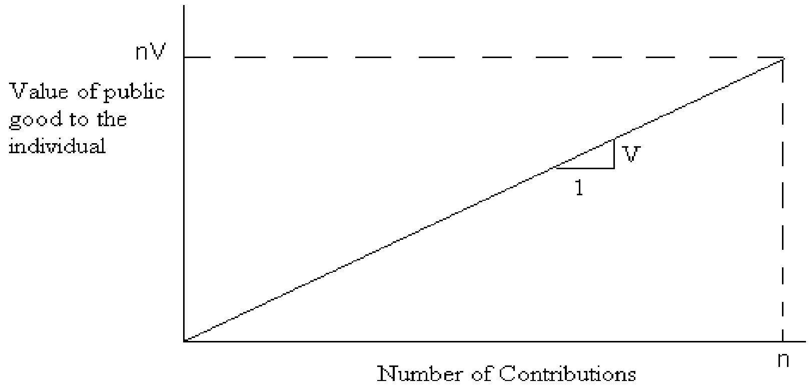

Figure 3

		Player 2: Contribute	Player 2: Not Contribute
Player 1	Contribute	***2V – C, 2V – C***	***V – C, V***
	Not Contribute	***V, V-C***	**0, 0**

The three defining assumptions of the 2-person PD translate easily to the *n*-person case. A non-excludable water project will entail an *n*-person PD whenever individual contribution to the public good implies a net cost ($V - C < 0$), individuals benefit from an outcome of joint contribution ($nV - C > 0$), and there is an incentive to free ride while everyone else contributes : $(n-1)V > nV - C$

When these assumptions hold, non-contribution is a strictly dominant strategy for all players, so that mutual non-contribution is a Nash Equilibrium. The equilibrium is clearly Pareto-inferior. If all players were to contribute, the resulting outcome (a successful water project with pay-off $nV - C$) would constitute a significant improvement on the status quo (no water project and a payoff of 0).

5. Community-based deterrence of free riders

Since projects are intended to function without ongoing support from government, the onus for deterring free riding lies with the community. Deterrence of free riding can be achieved through both 'formal' and 'informal' means. Formal deterrence typically involves the levying of fines by village water committees (e.g. Dreyer, 1998). Informal deterrence involves the use of social pressures to induce free riders to change their behaviour. In community-based projects, the latter form of punishment may be of considerable importance. Cain *et al* (2000) point out that community-based organisations frequently lack the authority to implement a system of fines on non-payers. This lack of authority is due to the fact that projects are operated by 'ordinary people', not policemen or other agents of the state. In an experimental economics paper, Van Soest and Vyrastekova (2004: 2) argue that:

> "Ordinary citizens do not usually have the right to break or destroy another's property, nor do they have the authority to impose fines: it is the government that has, in most societies, the exclusive right of coercion. What citizens *can* do however, is cease interaction with individuals who free ride in the social dilemma situation, and refuse to cooperate with them in other social or economic circumstances in which they meet".

This conclusion is supported by instances from real life. In the Eastern Cape's Crossroads community water project for instance, non-payers suffered the humiliation of having their social events boycotted (van Schalkwyk, 2000). Effective deterrence of free riders is likely to involve a combination of formal and informal mechanisms. Where strong social pressures work to deter free riding, the task of imposing fines becomes less critical. Water committees will thus be spared the ardous task of imposing discipline single-handedly onto the community.

In this paper, we model informal punishment. A common feature of informal punishment is the severing of social or economic links with free riders. Individuals who free ride may thus 'fall out' with their community, forgoing the benefits from everyday interaction with contributors.

The complexity of a public goods model depends on the period of time over which interaction is assumed to occur. We model the problem as a *1-period* game – thus assuming that contributing to the project is a once-off decision. In reality however, the decision to contribute to a water project is made on a monthly basis, repeated whenever tariffs become due. An infinitely repeated game may thus be a more realistic representation of a water project scenario. The modeling of infinitely repeated games is exceedingly complex however. In this paper, our strategy will be to use predictions from the one-shot model to shed some light on the scenario with repetition.

6. A One-period model with informal deterrence of free riders

In a small rural community, individuals are likely to receive substantial psychological and material benefits from their social ties with others. When these ties are withdrawn, diverse facets of an individual's well being are damaged (Baumeister and Leary, 1994).

Our model will assume that players in the public goods game are linked to each other by social ties, and that contributors have an option to punish free riders by breaking social ties with them. The nature of ties in the community is as follows:

- Each player is linked to each other player by a social tie. Thus for all *i:* player *i* interacts with all *j* where $i \neq j$. Every player is thus endowed with (n-1) ties, where n is the number of players.
- The social tie between player *i* and *j* provides both players with a payoff of *k* per period.
- Each social tie is of equal strength. Thus the tie between players *i* and *j* provides a mutual payoff of *k,* for all *i* and *j.*
- A player's total payoff from ties with the other (n-1) individuals in the community, *K* is the summed period payoff from each individual tie such that:
  $K = (n-1)(k)$.
- A player may 'punish' a free rider by breaking their social tie for that period. Punishment imposes a cost *k* on the free rider, but also implies a social cost to the person carrying out the punishment. The punisher forgoes the benefits from social and economic interaction with the free rider. We assume that this cost is *k*, i.e. that the cost incurred by the punisher equals the cost imposed on the free rider.

We now have a very simple measure of the benefits that each player derives from interaction with others in circumstances outside the public good context[3].

Returning to the case of the *n*-person community in section 4:

The project functions for just one period. The period is divided into two stages. In stage 1 individuals choose whether to contribute to the project. In stage 2, contributors learn the identities of free riders[4] and have the option of sanctioning free riders by breaking social ties with them.

The difficulty associated with informal deterrence now becomes apparent. If player *i* has chosen to contribute to the project in stage 1, she must choose whether to punish free riders in 2. Punishment is costly, since player *i* loses a valuable social tie each time she sanctions a free rider. Because 2 is the final stage in the game, contributors in the community do not gain any material benefit from sanctioning free riders – although this may not be the case when the project is repeated and punishment induces cooperation in the future. Rational players will choose not to sanction free riders, so that the game reduces to a standard 1-shot *n*-person PD, with a Nash Equilibrium of mutual non-contribution.

This is shown more formally below, using a game tree. At stage 2, player *i* makes a decision based on:

- the observed number of free riders (non contributors) in stage 1
- her expectations as to how many of those who contributed in stage 1 will punish free riders, and how many will tolerate (not punish) free riders.

[3] Incidentally, *K* can be seen as a measure of a player's social capital. The 'network payoff' conception of social capital is defined by Paldam (2000, 11) as follows:
"The social capital of person p_i is the total amount of benefits p_i can draw (without collateral or high interest rates) on his networks if necessary".

[4] This may occur by having the names of non-payers read out at community meetings, as was the case in the Tsita community (van Schalkwyk, 2000).

Let:
σ = expected number of punishing contributors
φ = expected number of tolerant contributors
(n-1-φ-σ) = observed number of free riders

The game tree, from player *i*'s perspective, is shown below. Payoffs are represented at the terminal node. The payoff at each terminal node is divided into a 'social' payoff, which represents the value of the player's social ties at the end of the game, and a 'project' payoff, which represents the payoff provided by the public good plus the net benefit from contributing (which, as before, is assumed to be negative).

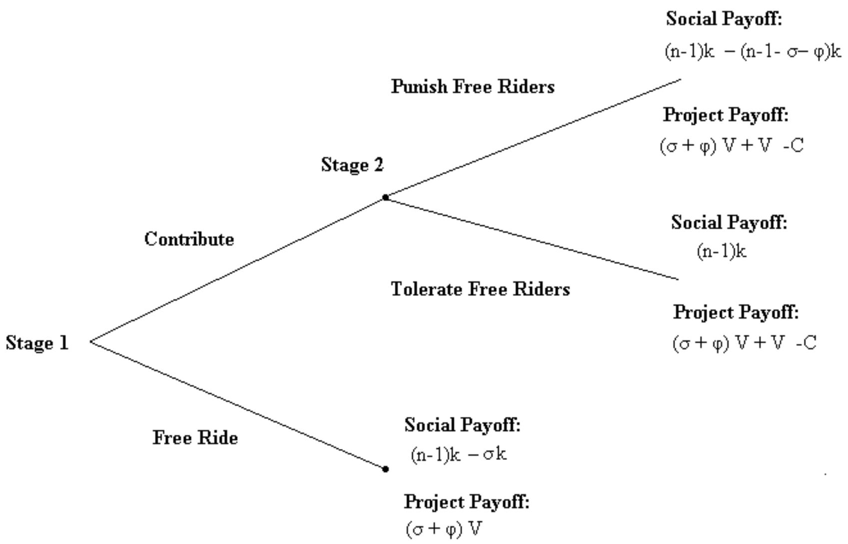

Figure 4

Using backward induction:

At stage 2, it is easy to see that *Punish free riders* is weakly dominated by *Tolerate free riders.* Unless there are zero free riders in the community (i.e. σ + φ =n-1), which entails that the expected payoffs provided by these two strategies are equal, the tolerant contributor enjoys a higher social payoff than the sanctioning contributor. This is because she never has to sacrifice valuable social ties to punish free riders. *Tolerate free riders* is thus a best response at the decision node in stage 2. Since the player knows that other players are rational, she is aware that every player follows reasoning identical to hers, so that no player will sanction free riders. She thus assigns a σ value of zero. In other words, she is perfectly confident that no one will punish anyone.

Substituting σ = 0 into her payoff function (with the *Punish* strategy now omitted from consideration), player *i* realises that her decision whether to contribute to the project no longer affects her social payoff (since there is no expectation of punishment). Her social ties are preserved regardless of whether she contributes, so that she earns a social payoff of (*n*-1)*k* either way. However, the *Free Ride* strategy yields an unambiguously higher *project* payoff. The *Tolerate* Strategy is financially costly ($V - C < 0$). As a result, player *i* eliminates *Tolerate* from consideration, choosing the remaining strategy on her list: *Free Ride*. By identical reasoning, others in the community also choose this strategy.

The (pessimistic) conclusion implied by the one-period model yields a key insight. Projects implemented by external agents are undoubtedly a source of conflict in communities. The threat of antagonism between payers and non-payers puts valuable relationships at risk. Close-knit communities may fail to comply with a project even when it has the potential to offer a valuable service. This conclusion has support in the case study literature. Dreyer (1998), reports examples of communities that chose to abandon formal water projects in favour of returning to traditional sources, in order not to risk the prevailing sense of harmony in the community. A desire to preserve social ties thus leads to an equilibrium outcome of zero contribution.

7. Conditional Cooperation: the impact of social norms

The conclusion that the costliness of punishment prevents a community of *rational* players from producing public goods is not a novel one. Ostrom (2000) and Fehr and Gachter (2000) have made the same point. This brings us to a somewhat unsatisfying conclusion: community-based provision of public goods is *never* possible if coercion rests entirely upon social relations (rather than, say, coercion by the state). While many water projects failed to harness cooperation from beneficiary communities, many succeeded (Dreyer, 1998).

A common explanation for the occurrence of contribution employs the concept of *social norms*. Free riding violates socially entrenched conceptions of morality, such as fairness (Fehr and Schmidt, 1999) and reciprocity (Fehr and Gachter, 1998). Free riding by members of the community may generate feelings of moral disapproval among contributors. Individuals are willing to use punishment to express this disapproval and enforce norms, even when punishment is costly and does not provide any personal gain (Gintis, 2000). Experimental evidence by Fehr and Gachter (2000) and Carpenter and Matthews (2005) support this conclusion. This fact is also witnessed in every day life. As noted earlier, non-payers in the Crossroads community had their social events boycotted. Elsewhere, fishermen in the Bahia region in Brazil are reported to destroy the nets of fellow fishermen who do not adhere to quotas (Cordell and McKean, 1992, cited in Van Soest and Vyrastekova, 2004). Of course, if *everyone* is morally opposed to free riding, there would be no free riders. Yet perfect adherence to norms seems unrealistic. It appears that a key motivation for individuals punishing free riders is the desire not to be 'suckered' into contributing while others free ride (Fehr and Gachter, 2000). There are two ways to avoid being 'suckered' in the public goods scenario: one either punishes free riders or free rides one's self. Contributing, whilst tolerating free riders is clearly not an option. It is this scenario that we choose to model.

Assume that all individuals in the community are motivated by an appropriate social norm (say, *fairness*) so that costly punishment is credible. The social norm prevents contributors from choosing the *Tolerate* option in stage 2. By contributing to the project in stage 1, a player thus signals a willingness to punish free riders in stage 2. The strategy space available to player *i* is thus as follows:

Contribute and punish free riders = *Sanction* Strategy
Free ride = *Free Ride* Strategy

The game is now much simpler to analyse, because the decision is made at stage 1) only. Let σ = the expected number of punishing contributors in the community

n-1- σ = the expected number of others in the community playing *Free Ride.*

Player *i*'s payoff function is now as follows:

Strategy:	*Expected Project Payoff: (Stage 1)*	*Expected Social payoff: (Stage 2)*
Sanction	$\sigma V + V - C$	$(n-1)k - (n-1-\sigma)k$
Free Ride	σV	$(n-1)k - \sigma k$

An important implication of the payoff function above is that players will be conditional cooperators. Define *D* as the payoff differential between the *Sanction* and *Free Ride* strategies (= total expected utility from *Sanction* – total expected utility from *Free ride)*. Player *i* will choose *Sanction* when it offers the superior expected payoff, i.e. when D > 0. This is the case when:

$$(n-1)k - (n-1-\sigma)k + \sigma V + V - C > (n-1)k - \sigma k + \sigma V$$

Simplifying, the inequality becomes:

$$\sigma > -(V-C)/\ 2k + ½\,(n-1) \qquad [\text{s.t. } \sigma \leq n-1]$$

This suggests that *Sanction* is a best response by player *i* to the strategies of the other players when the number of others (σ) playing the *Sanction* strategy *is sufficiently more than ½ of the other players*. Given that *V-C*, (the net benefit of contribution) is negative, and *k*, (the value of a social tie) is positive, the first term on the RHS of the inequality is positive. σ , the proportion of one's fellow community members playing *Sanction* must therefore exceed ½ (*n*-1) by the amount - *(V-C) 2k*.

This implies that the player *i* is subject to a 'tipping' effect. This effect is illustrated below:

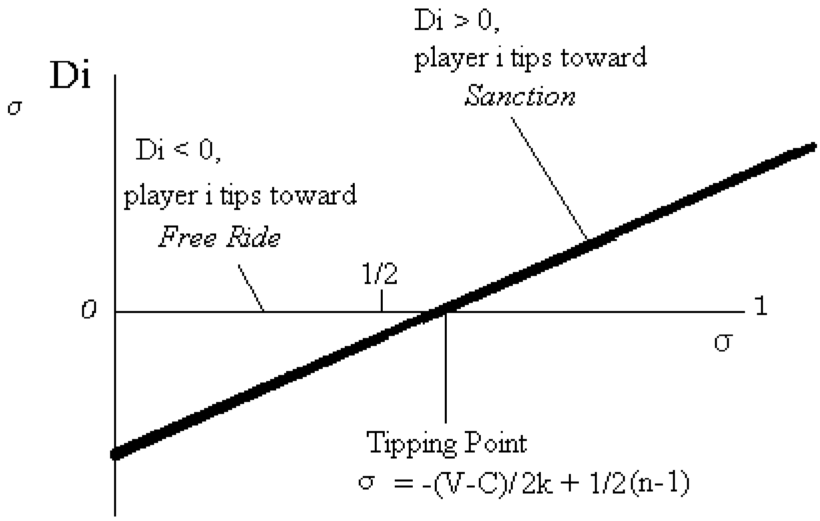

Figure 5

We need to specify the restriction that σ ≤ n-1, because there are only n-1 other players. The sum of the two terms on the RHS thus cannot exceed n-1 which implies that - (*V-C*) ≤ (*n-1) k*. This inequality states that in order for *Sanction* to be a viable strategy the net cost of contribution must be less than the total value of social ties. *Sanction* can *never* be an optimal response if the net cost of contribution is less than the value of social ties.

Our model thus suggests that joint contribution by the community will be a Nash Equilibrium when the following conditions hold:

i) Social norms within the community are strong enough to ensure that punishment of free riders is credible.

ii) The net cost of contributing to the project - (V-C) is less than or equal to the value of a player's social ties in the community.

When the above hold, there are two Nash equilibria: mutual cooperation and mutual defection. The equilibrium that is reached will depend on the value of σ. This can be shown most clearly as a one-shot 2-person game.

We assume, without loss of generality, that V = 3, and C =5 [5], with the network payoff earned by each player from his social tie with the other = 4. The interaction between the two players has the structure of a stag hunt (assurance) coordination game (see Skyrms and Irvine, 2001) as shown:

[5] By inspection, assumptions 1) to 3) of the PD can be seen to hold true.

		Player 2: Sanction	Player 2: Free ride
Player 1	Sanction	**<u>5, 5</u>**	**-2, 3**
	Free Ride	**3, -2**	**<u>4, 4</u>**

In the stag hunt, there are two pure strategy Nash Equilibria: mutual sanctioning and mutual free riding, as underlined above. A key implication of the stag hunt is that a player will play the cooperative strategy (*Sanction*) *only if she expects the other player to do so*. If the other player free rides, she will behave likewise. Players are thus *conditionally cooperative*, a result that broadly agrees with experimental findings (Keser and van Winden, 2000).

In order to guarantee the Pareto superior outcome, players need to coordinate their actions. When player 2 announces his decision to play *Sanction*, player 1's best response is to play the same strategy. In a 1-shot game with n players, player i will play *Sanction* when the expected number of others complying with the project exceeds - $(V\text{-}C)/\ 2k + ½\ (n\text{-}1)$. The conclusion that the proportion of others playing *Sanction* must exceed ½ is in agreement with game-theoretic literature on coordination games. In the above game, Free Ride can be classed as a 'risk dominant' strategy. Given a 2-person game with binary strategy choices, Harsanyi (1988) define a risk dominant strategy as one that would constitute a best response if one's opponents randomise such that each plays either strategy with probability ½. Using an evolutionary model, (Kandori *et al* , 1993) show that the basin of attraction for the risk dominant equilibrium is larger. The non-risk dominant strategy is a best response only when more than ½ are already playing it.

8. Dynamic implications

In this paper, we have analysed the public goods problem as a simple 1-period game. In reality, an infinitely repeated game may be more appropriate - projects are intended to function indefinitely over time, with tariff contributions due each month.

In the model with social norms, the lesson from the one-period game transfers fairly easy to the repeated case. The fact that joint contribution is a Nash Equilibrium in the 1-shot game implies that it can be stable in the infinitely repeated scenario. In a community where social norms are strong enough to ensure that punishment of free riders is credible, a convention for playing the one-shot strategy '*Sanction*' in each period of the infinitely repeated game will be stable. No player can do better by breaking the convention – this would result in him losing most of his ties with the community.

The basic result of the one-shot model with social norms – that the proportion of contributors in the community should be sufficiently high at the beginning to ensure joint cooperation – holds true in an infinitely repeated scenario. If contribution levels are sufficiently high at early stages, a player who free rides will find herself isolated by the majority of the community. By contributing in future rounds, she can regain the social ties lost in previous stages. She will become a contributor when the value of ties restored by contributing outweighs the monetary and social costs of contributing (the latter involves breaking ties with free riders in the community). Assuming that σ – the expected number of individuals playing *Sanction* equals the number of players who employed this strategy in the previous round – the value of tie restored will be – (V-C). The monetary cost of contribution is – (V-C) and the social cost of breaking ties with free riders will be $(n\text{-}1\text{-}\ \sigma)k$. Free riders will thus be induced to contribute in future stages when:

$$\sigma k > -(V\text{-}C) + (n\text{-}1\text{-}\ \sigma)k$$

i.e. $\sigma > -(\text{V-C})/\ 2k + \frac{1}{2}\,(\text{n-1})$

In section 6 of this paper, we showed that contribution to the project was not feasible in a once-repeated when social norms *were absent*. It is not clear to what extent this result will differ from that of a repeated game were norms *are absent*. In the one-shot game, threats to punish free riders will not prove credible, because punishment is costly. In the infinitely repeated game the credibility problem may be less severe – costly punishment may induce future cooperation and thus provide an offsetting benefit to the punisher.[6] There may nevertheless be a credibility problem – punishment is a public good in itself, and contributors may be tempted to leave the task of punishing free riders to others.

9. Policy implications

Assuming that community-based service provision is desirable, what policy measures should government and development agents take to deter free riding in projects? Drawing from our model, we identity three conclusions:

9.1 The importance of community mobilisation

When community projects are implemented incorrectly, they have the potential to put social relationships under threat (Dreyer, 1998). Our revised public goods model (with the assumption of credible punishment) demonstrated that contribution by individuals who value their relationships with others is feasible only when mutual expectations of contribution by others are sufficiently high. An important task for the implementing agent is to ensure that the appropriate mutual expectations are developed within the community. Members of the community thus need to demonstrate *to each other* their willingness to contribute to the project. It is argued that many rural communities are characterised by a *culture of non-payment* (Hemson *et al*, 2004), with members displaying an attitude of apathy to public projects. Community members are thus unlikely to expect others to contribute. Players will assign a low value to σ. If the culture of non-payment hypothesis is true, it is vital for project agents to work to change these expectations.

[6] Carpenter and Matthews (2005) indicates that punishment can be consistent with the Folk Theorem (trigger strategies) over repeated interaction in certain environments.

A potential solution is the 'emergency fund' project rule, promoted by South Africa's Mvula Trust NGO until 1998[7] (Palmer, 1998). Under this rule, communities were expected to raise an amount equivalent to 5 % of the project's capital costs before the project got underway (Palmer, 1998). These funds were used as savings to insure against emergency project breakdowns in the future. The funding requirement can be an effective mobilisation tool. To see why, imagine the scenario from the perspective of player *i*, who must decide which of the two available strategies (*Sanction*) and (*Free Ride*) yields the highest expected utility. Prior to the water project's implementation, the implementing agent requires the community to collectively raise an amount equivalent to 5% of the project's capital costs for the fund. Suppose that the required amount is R5000. The water committee asks 250 of the community's 300 households to pay a R20 contribution in order to ensure that the requirement is met. Assume that the committee's drive is successful, and the project gets underway.

Since 83% (250/350) of adults in the community have demonstrated their commitment to the project, player *i* will expect a similar proportion of the others community to adopt a '*Sanction*' strategy (assuming that a social norm generating costly punishment is in place). If this proportion exceeds the minimum value needed to mobilise player *i*, then the project rule is effective.

Alternatives to the emergency fund rule may involve voluntary contributions of labour at the construction stage (e.g. Sara and Katz, 1998), or well attended community meetings where members have an opportunity to express their commitment to the project.

9.2 Strengthen social capital before the project gets underway

The stronger the social capital in a community, the easier it is to mobilise members to contribute to the project, assuming that the appropriate social norm is in place. This is demonstrated as follows:

Let $\overline{\sigma}$ be the 'tipping point' necessary to mobilise player *i* to contribute. As demonstrated in section 6,

$$\overline{\sigma} = -(V - C)/\ 2k + ½\ (n\text{-}1)$$

The value of a player's tipping point is a measure of how difficult it is to mobilise her to contribute. A community where members typically contribute only if convinced that the proportion of others doing likewise is at least 0.9 will prove much harder to mobilise than a community where member's tipping points only marginally exceed 0.5. A player's tipping point is negatively related to the quality of her relationships with others in the community. This is shown using comparative statics. We isolate *k* (the value of a social tie) as the key explanatory variable, since this measures the benefits to player *i* from typical interaction with others in the community.

$$\partial\overline{\sigma}\ /\partial\ k_i = \ [(V–C)\ /\ 2]\ k^{-2}$$

[7] The rule was withdrawn under pressure from the Department of Water Affairs and Forestry.

Given that $V - C < 0$, and $k > 0$, it follows that:

$$\partial \, \overline{\sigma} \; / \; \partial k < 0$$

Therefore, the higher the quality of a player's relationships with others, the more easily she can be persuaded to contribute. Communities characterised by strong social ties will thus prove easier to mobilise. The logic behind this result is simple. In projects where community ties are strong, members have more to lose from punishment by their fellows, and are thus more easily influenced to contribute by the threat of punishment. The implication for policy is simple: social intermediation to improve the level of social capital in the community will increase the likelihood of overcoming the free rider problem. Efforts by social intermediaries to foster the growth of networks such as women's groups and church organisations may thus be a desirable development strategy.

9.3 Increase project value, or improve cost effectiveness

The difficulty associated with mobilising a community to contribute increases when the financial cost of tariff contributions (C) increases, and decreases when the value of the project increases.

The model's comparative statics shows that the minimum proportion of contributors necessary to mobilise a player to contribute is an increasing function of the cost of tariffs:

$$\partial[\overline{\sigma} \; /(\text{n-1})]/\partial C = 1/2k$$

This suggests that efforts to make projects more cost effective will decrease the risk of projects encountering the free rider problem. For instance, projects that source water from gravity springs are far cheaper to operate and maintain than projects that use diesel pumps to pump water from boreholes (e.g. Still *et al*, 2003). The more valuable a project, the higher the value of V, which represents the incremental value added by one contribution. This is shown below. A project that offers a comparatively high value when joint contribution is achieved has a steeper production function, thus entailing a higher value for V (the slope of the linear function).

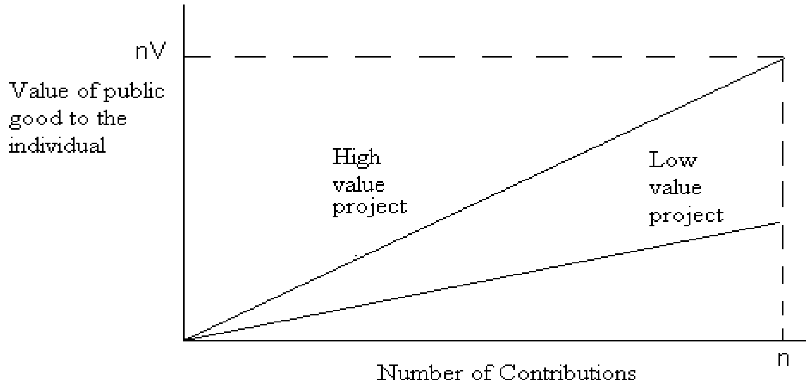

Figure 6

Comparative statics suggests that:

$\partial \overline{\sigma} / \partial V = -1/2k$

The negative value of the derivative suggests that mobilisation of the community will prove easier for projects with a higher value. This suggests that where possible, projects must be carefully planned to provide maximum benefit to the community. For instance, the location of standpipes should be planned to ensure maximum convenience.

10. Concluding Remarks

The three policy implications presented in this paper suggest an approach that emphasises institution building, community mobilisation and social intermediation. In some ways, these recommendations are uncontroversial. They are cornerstones of the 'demand-responsive' approach to community-based water services, advocated by South Africa's Mvula Trust (Palmer, 1998). At the same time, these implications may have some relevance in explaining project failure in South Africa. At the forefront of much of the South African debate is a feeling of unease about the 'supply-orientated' approach implicit in the practices of the Department of Water Affairs and Forestry (Palmer, 1998; Webster, 2001). It is alleged that projects were implemented (often with great publicity and fanfare) despite little or no prior consultation with communities[8] (Louw, 2003; Breslin, 1999; Dreyer, 1998). Using the logic expressed in this paper, this approach is deficient because it ignores the importance of community mobilisation and efforts to build community ties. At the core of government's approach is a very understandable *impatience*. In the rush since 1994 to supply water infrastructure to the 12 million people who so desperately needed it, implementing agents paid little attention to consulting with communities (Louw, 2003; Emmett and Hagg, 2003).

The future of South Africa's rural development approach hangs in balance. Recent policy pronouncements have abandoned the traditional emphasis on community-based service

[8] This is in spite of the fact that policy explicitly required projects to be demand-driven, with the operation and maintenance costs met by the community (DWAF, 1994)

provision, and have focused on bolstering local government (Hemson *et al*, 2004). This seems sensible, since access to adequate municipal capacity is a basic democratic right. At the same time, utilising civic involvement to supplement local government efforts may be desirable. If community-based services are to work, project agents should possess the patience and social skills necessary to integrate projects into community life.

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