Constitutional Choice for Common Property Managements The Case of Irrigation Associations

by

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I. Introduction

Massive investments in irrigation facilities by developing countries and largely funded by international and bilateral donor agencies attest to the belief that irrigation is a key weapon in the battle against world hunger and poverty. Yet ex post evaluation of irrigation projects tell a disappointing story. Benefits *are* typically vastly below the projected levels.

In the literature that has grown up around this problem, the most commonly cited symptom of poor water management is "organizational failures." Some progress has been made towards generating principles for the successful organization of irrigation systems by studying indigenous water user associations that have evolved largely independently of the plans and programs of central governments.

While some authors make reference to the free rider problem and other principles of public choice theory, there has not been an explicit attempt to understand irrigation associations with the aid of a rigorous normative framework. This paper is the product of such an attempt.

A framework for determining the optimal organizational form for an irrigation association is developed using the principles of maximum producer surplus and minimum agency cost. This framework is used in interpreting documented cases of successful and unsuccessful associations and to illuminate some principles of efficient provision of irrigation. - These principles appear to be of some general use for the efficient management of local public goods.

II. The optimal water-user association

Normative economics is the -first (and sometimes the last) step in positive economics. That is, we use optimal behavior, under various assumptions, as a guide in explaining actual behavior. This section is motivated by that approach. Specifically, we seek to understand how a group can optimise with respect to group membership, determination and allocation of costs and benefits, decision—making mechanisms, and sanctions to enhance compliance.

Imagine a uniform section of land, differentiable only by its proximity to a river. It is possible to construct a diversion canal of variable depth and length to irrigate part of the land. There are economies—of-scale in constructing systems of increasing capacity (measured e.g. in cusecs, cubic feet per second delivered at the head) but increasing costs of delivering the water to more distant points from the river.

The optimum size of the irrigation facility is illustrated in figure 1. Total marginal costs (TMC) *are* comprised of declining marginal construction costs (MCC) and rising marginal delivery costs (MDC). Producer surplus is maximised where marginal benefits, given by the demand curve, D, equal TMC. Assuming that D intersects TMC in its declining portion as shown, marginal cost pricing leaves a deficit to be financed by the lump—-sum portion of a two-part tariff.

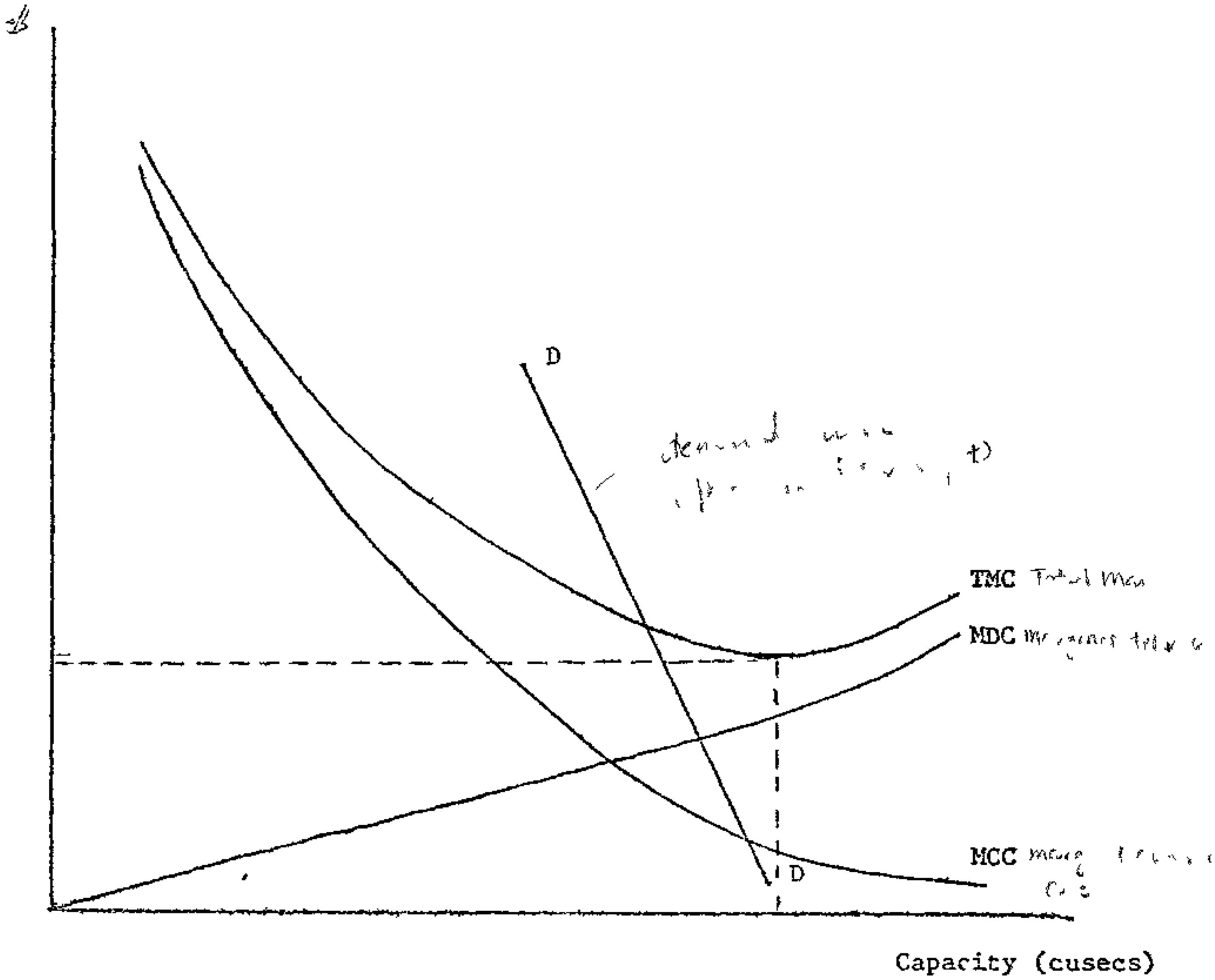

Figure 1:

Optimum capacity without transaction costs

To be efficient, the deficit must be made up in a way that does not discourage any potential members from participating in the association. That is, every member's share of the deficit must be less than his total surplus. This can be accomplished by finding that share of surplus, such that the aggregate contribution by members just makes up for the deficit. If there are a number of possible channel locations, then ex ante competition among alternative contractual arrangements will tend to limit the extent to which any individual has to pay higher than the average share.

Maximum benefits generated by the irrigation association *can* be defined with reference to the marginal member. For the marginal member, the marginal cost of producing an extra cusec of water plus the marginal delivery cost is just equal to the marginal benefit (product) of water. Since the marginal producers surplus is zero, the optimal membership fee for the marginal member is *zero.* Having determined N and the vector of membership fees, maximum producer surplus is determined for each C. The marginal producer surplus curve is the marginal benefit to the irrigation association and is shown in figure 3.

Coalition costs may be defined to include the costs of information and enforcement. Borrowing from the positive agency literature, coalition costs may be taken as the total agency or organizational casts for collective action. That is, coalition costs include the costs of monitoring and bonding to reduce "shirking" (i.e. deviations from first-best performance) plus the residual losses from the shirking that is not avoided.

For a particular organizational form, optimal monitoring and bonding expenditures are determined according to the principle of minimum agency costs, illustrated in figure 2. Total agency costs, AC, are defined as the sum of monitoring/bonding costs, MBC, and "shirking" costs, SC. Optimal monitoring/bonding occurs at M* where AC is at a minimum. If several organizational forms are possible, the optimal organization is the one with the lowest minimum agency cost.

At each level of membership, the coalition cast is the minimum agency cost of the optimal organization for that particular number of members. For example, as the number of members increases, it may be efficient to switch from informal, moral sanctions to centralized authority with specialized police power. On the other hand, it may also be efficient to switch from informal central decision-making in small groups to de-centralized decision—making in large groups. That is, the decision-making and enforcement mechanisms are endogenous features of the organization and may be co—determined with group size. Since agency costs are thus uniquely related to group size, the marginal agency or coalition costs can be constructed and drawn in figure 3. How along with the marginal benefits or producer's surplus (from figure 1), figure 3 illustrates the optimum group size. Since the other variables have been expressed as functions of N, this leads to a solution for optimal capacity, distribution, and organizational form.

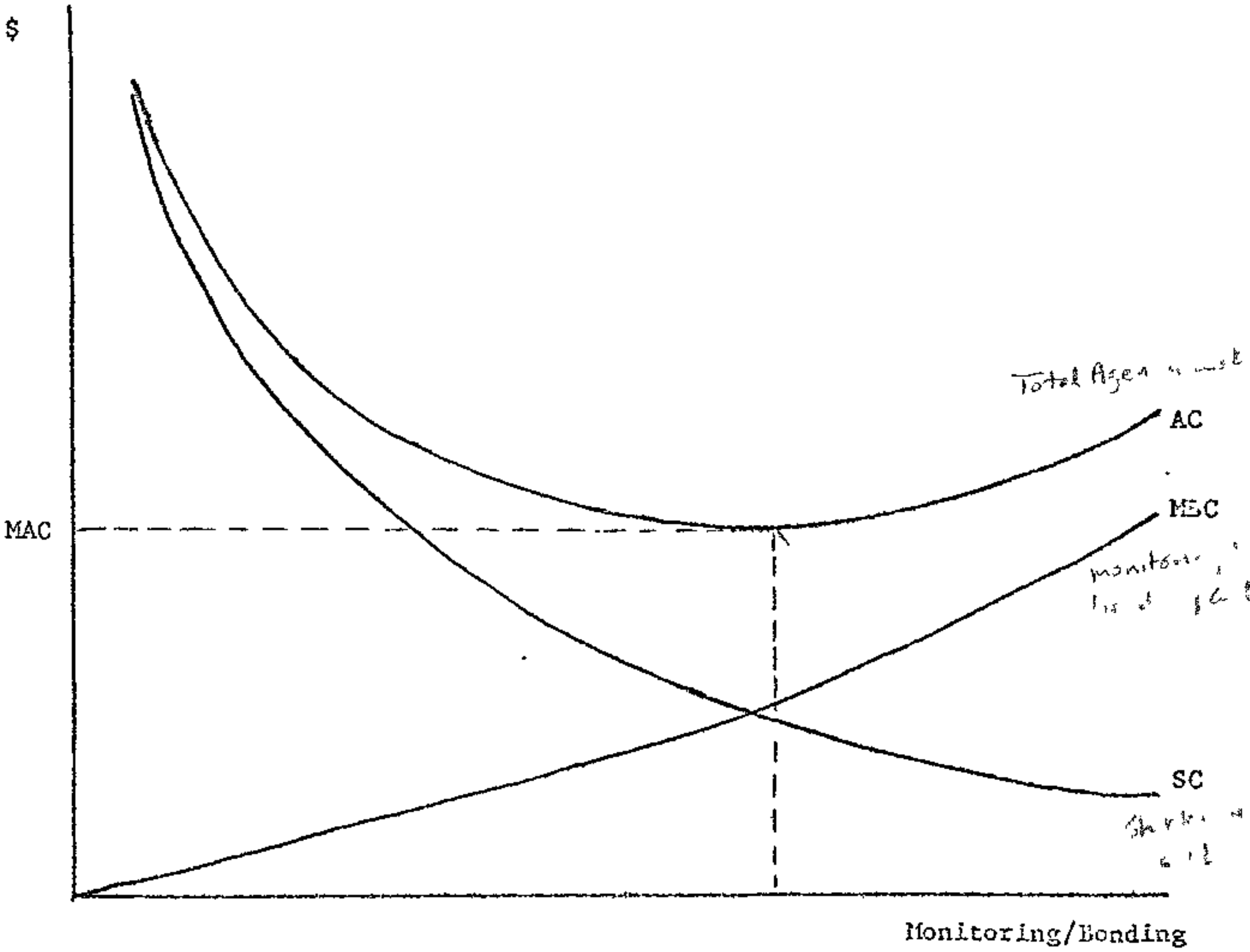

Figure 2

Minimizing Agency Costs by Optimal Monitoring

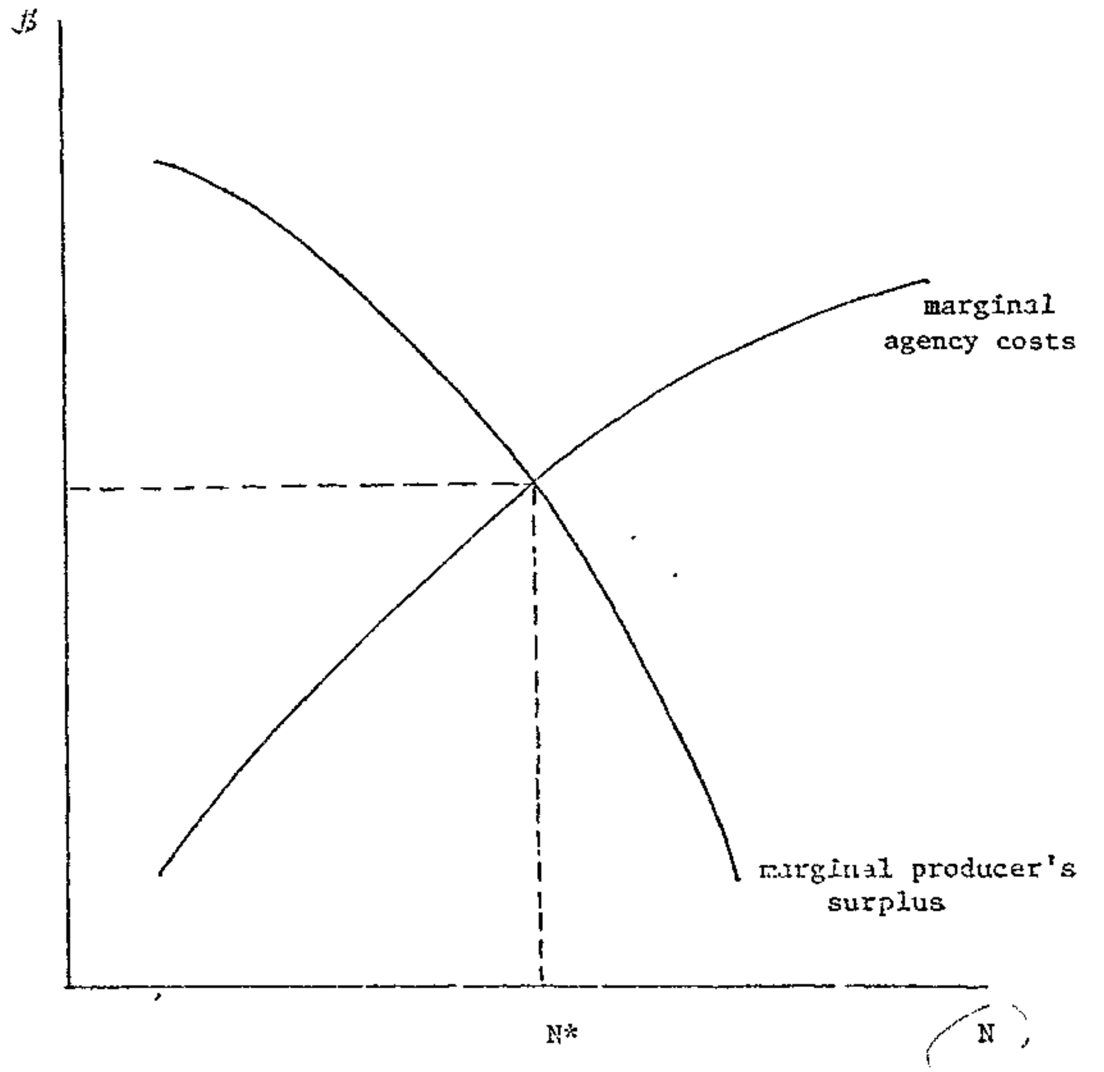

Figure 3 :

Optimal membership

These considerations provide a framework far understanding differences in contractual arrangements across groups, i.e. for constitutional choice. By examining particular group contracts that arise among irrigation associations, it may be possible to discover stylised patterns relating the organizational form to characteristics of the environment and to infer restrictions in our conceptual framework that generate these relationships in theoretical propositions.

Before turning to case studies, however, it is useful to see what a priori, propositions *are* implicit in the conceptual framework. Returning to figure 1, recall that irrigation systems with higher capacities facilitate the inclusion of members with increasingly distant farms from the water source. The more distant farmers, called "tail enders" in the irrigation literature, should pay higher delivery fees *per* unit of water delivered but lower membership fees.

Since it is costly to give discretion on the amount of water delivered to each farmer and then to meter the amount of water actually delivered, the allocation decision may be made centrally. The association manager can ration water so as to (approximately) equalize the net (of conveyance losses) marginal product of water across farms. This permits a user fee to be levied on the total amount each farmer is allotted.[1] Furthermore, for administrative convenience, the membership fee may be

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[i] More generally, as Abba Lerner and others have observed, marginal cost pricing is not inconsistent with central planning.

lumped together with the user charge. Thus the apparent absence of an explicit user fee does not imply inefficiency. What is important is to ration water such that the marginal product of water, net of transmission losses, is equal across farms.

III. Some examples

Observation is more productive of insights and generalinations when guided by a normative framework. Despite the fact that the existing irrigation literature is not so guided, it is still possible to extract some preliminary propositions of interest.

Regarding water distribution, most government-designed systems are based on the principle of equal quantitites of water per unit of irrigated land (Bromley, et. al., 1980). Land area is also the most common method for allocating water in communal systems, followed by amount of seed planted and yield, the latter two being quality-adjusted proxies for land area (e.g. de las Reyes, 1981).

Since equality of water consumption, in the face of transmission losses, violates one of the efficiency principles developed above, this observation arouses some interest. Under close scrutiny, the claim of equal distribution becomes difficult to sustain. First, the equal distribution rule in large government constructed systems operates in design but not in practice (Bromley, et al., 1981). Second, in carefully monitored systems, equality may be implicitly defined in terms of total water "sent," i.e. water actually delivered plus losses in transmission (Martin and Yoder, 1983) , instead of water "received."

In other systems, water delivery is not designed to be equal. For example, water in a system in Chherlung, Nepal is allocated according to the principle of number of shares purchased by the water user (Martin and Yoder, 1983). This allows benefit -Financing to operate directly. In a system in Ilocos Norte, Philippines, tailenders *are* allocated less water than farmers near the head during times of scarcity. But the farmers with less water grow less water-intensive crops, typically garlic, and still earn good incomes. It appears that equal division of water would result in substantial yield losses for rice farmers without compensating increases on other farms (Siy, 1983).

Irrigation systems in developing countries *are* often poorly designed, especially those provided by the central government. Not only do systems combine culturally distinct groups, who may even be in conflict, but even the physical engineering is often poorly done (see e.g. Bottrall, 198l). These failures in design are partially offset by changes in the way the system actually operates. For example, farmers at the head often take more than than their prescribed allotment of watar and channel that water to other farmers who are not part of the formal system. Thus what is apparently a situation of gross inequity between the head and tailenders is actually a partial compensation for failures

failures in design.

The extent of formal hierarchical organisational structures and decision-making mechanisms is largely a -function of group size. In a survey of communal irrigation in the Philippines, de los Reyes (1981) notes that groups with total farm holdings of less than fifty hectares tend to use informal decision-making mechanisms relative to large associations.

> In systems under fifty hectares, ... users *are* easily able to discuss and plan among themselves the distribution of water. (In larger systems, the task of allocating water is typically delegated to a team of water distributors.) The team leader is responsible for distributing the water from the dam to all parts of the system.... Other water distributors are assigned to allocate water within their respective areas (de los Reyes, 1981, p. 4).

Similarly, farmers in small systems schedule maintenance on an ad hoc basis, as the need arises. In larger systems, frequent and regular maintenance schedules are more common. Collection of fees is formally prescribed and delegated to designated collectors and treasurers in large systems (de los Reyes, 1981).

There is undoubtedly some confounding of causes in the "small is flexible" observation. Some degree of specialisation in decision-making and administration is a natural consequence of

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2 Similarly, black markets often compensate for market distortions invoked by misguided development planners. It is presumably rare, however, that planners will be grateful for the way the system minimizes the costs of his errors in design. Rather one expects the planner to do everything in his power to harass and punish the black marketeers or water "thieves" who he sees as marring the beauty of his grand design.

size. On the other hand, the degree of government involvement tends to be greater in larger systems. Part of the formal hierarchical structures of large systems is undoubtedly due to the "planners' bias" of government controlled systems.

A related issue in prescribing and explaining organisational form or "constitutional choice" is the question of optimal federalism. There *are* two basic motivations for federalism in irrigation associations. One is to the extent that large groups suffer diseconomies-of—scale in management, they can be divided into subgroups. Another is that irrigation systems *are* typically hierarchical by virtue of their physical layout. Thus in China, for example, communal groups *are* organised around the subbranches of the system, and there are distinct government functions at the main branch level and at the dam and main canal level(Nickum, 1982).

In Ilocas Norte, farmer groups called "zanjeras" *are* organized into a federation of zanjeras. A water council operates at the federation level to determine water allocation among the zanjeras, There is substantial inequality in the amounts of water allocated between zanjeras but no reason to suppose that this leads to either inefficiency or injustice. Farmers in less favored zanjeras also contribute less to the maintenance of the main canal (Siy, 19S3).

Several associations in the Philippines were able to invoke sanctions to insure reasonable performance of the members. In the early 1900's, these included physical punishment and confiscation of land. More recently, moral sanctions, fines, and exclusion from the benefits of the association have been used to mitigate against shirking. Clearly, collectively provided goods *are* not necessarily plagued by the free rider problem.

On the other hand, the literature also provides ample evidence of abuse of the system, especially of gross inequities between the head and the tailenders. These examples are often associated with government designed systems. The problem here is that the enforcement powers of the central government *are* typically very weak in rural areas of developing countries.

The notion that effective government control requires a combination of force and legitimacy implies that compliance is enhanced by voluntary consent. Few central governments *are* able to enforce unpopular measures that require large sacrifices, such as collection of high irrigation fees from many of its citizens. On the other hand, village communities in many countries have very well-developed informal governments, with established legitimacy. Where irrigation associations are entirely within the jurisdiction of such governments, they *are* less likely to have enforcement problems. However, when a central government tries to impose a group constitution over citizens of different traditional jurisdictions, e.g. villages, then non-compliance is to be expected.

The best known case wherein central-government sponsored irrigation associations have succeeded is Taiwan. It is not a coincidence that local government in Taiwan was highly integrated with the central government and enforcement of association rules was highly effective.

IV Concluding Remarks:

The literature on irrigation in developing countries has established that while large, centrally designed and administered irrigation systems are typically quite inefficient, there are several examples of voluntary indigenous organisations that have solved the allocation and enforcement problems very effectively. The analysis and discussion above may help in understanding this phenomenon.

First, the determination of optimal water allocation and fee structures, even aside from enforcement and collusion costs, is extremely complex. The decreasing marginal costs of expanding the command are partially offset by the increasing marginal conveyance costs. However, since the pattern of these costs will differ across locations, it would be difficult to determine general principles of distribution and water-charges that could be embedded in "top—down" designs. Moreover, there are important interdependencies between users in conveyance. It is not that the first user imposes a technological externality on subsequent users as some authors have suggested (see e.g. Bromley, 1981) but that there are economies—of—scale in conveyance. There *are,* accordingly, efficiency gains to be had by coordinated water delivery.

Second, voluntary associations have a natural advantage in enforcement. Since the association will be embedded in the traditional structure of informal government (village elders, *etc.}*, moral sanctions, communication, and decision-making will all be facilitated. Centrally designed systems, dominated by (naive) principles of engineering and banking, have a tendency to combine groups from different informal jurisdictions. The centrally-imposed rules of operation are likely to be in conflict with the rules of the associated jurisdictions, which are also likely to be in conflict with each other.

An incidental dividend of this exercise has been the clarification of principles from normative public choice theory. We have seen that the benefits of expanding joint use of a productive input can be determined from the maximum producer surplus attainable by different sized groups. Collusion costs can be precisely defined as the minimum agency cost achievable with a group of given size. These two constructs provide a framework for generating comparative statistical propositions about organizational form. The inductive development of organizational theory will be enhanced by further empirical observation that is guided by a normative framework.

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Appendix: Notes on the theory of local public goods

Figure 3, or some variant thereof, is a central pillar of the public choice pardigm. For example, it is used to de-fine the optimal percentage of voters that should be constitutionally required to pass enabling legislation for public goods. In that case, the marginal benefit of requiring an extra vote is the reduction in "political externality costs" associated with log-rolling and related phenomena. The marginal coalition costs *are* the costs of negotiating for the approval of an additional voter.

But there is considerable ambiguity about the analytical foundations of the two curves. This is partly because there are implicit optimization processes underlying each of the curves. In the present paper, rather jump immediately to the application of figure 3 to irrigation, I have attempted to make the optimization problems explicit in figures I and 2.

The marginal producer surplus curve in figure 3 is defined with respect to the maximum producer surplus as determined in figure i. Moreover. the marginal delivery and construction curves (MDC and MCC) *are* themselves indirect functions. Delivery costs depend not only on the capacity in cusecs pf water at the head but also on the number and distance of the farmers in the irrigation system and the amount of water delivered to each. The optimal number of users is determined for each amount of water, C, by the amount of water delivered to each. The optimal number of users is determined for each amount of water, C, by the principle of equal net marginal value product, NMP. That is,

$$N = N^* \text{ implies } NMP_i = NMP_* \quad \forall \quad i,j \in S,$$

where,

$$NMP_i = MP_i - MDC_i$$

(or marginal product minus marginal delivery cost to the ith farmer). Thus,

$$MDC = f(N^*(c)),$$

i.e. the marginal delivery cost for the system as a whole is an indirect function of capacity.

Similarly, the marginal capacity cost, MCC, for the system depends on the size and distance of canals associated with the optimal distribution pattern, including the number of farmers, i.e.

$$MCC = g(N^*(c)).$$

MCC declines mainly because of economies of-size in bigger capacity systems.

This model also provides a generalization of Buchanan's model of local public goods for the case where the optimal *size* of the good is endogenous and marginal delivery cost is replaced by marginal congestion cost. Pure public goods represent the special. case where marginal congestion costs *are* zero and N is W_{max} (all citizens). The Tiebout model is the case where many identical clubs compete for members such that DD intersects the total average cost schedule (not shown) at its minimum.

None of these models accounts for coalition costs. Rather, by defining the maximum benefits for each number of members, it allows benefits of the coalition to be rigorously defined as a function of N. By defining marginal coalition costs as an independent function of N, as in figure 2. we have a framework for determining optimal group size and optimal organization of the public provision.