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On Financing Global and International Public Goods

Todd Sandler

Not all international public goods (IPGs) pose the same financial challenges. For some, encouraging adequate funding requires much ingenuity. For still other IPGs, incentives are consistent with the operation of markets or clubs; no official intervention is required as the IPGs are financed unofficially, with few transaction costs.

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Summary findings

Three dimensions of public goods—nonrivalry of benefits, the possibility of being excluded from benefits, and the technology for aggregating public supply—determine what kinds of institutions and transnational actions are required for their provision and financing. For some public goods—especially those for which the exclusion of nonpayers is not feasible—these properties are such that a public sector push is needed or the good will not be financed. This push can come from a supranational structure (such as the World Bank, the United Nations, or the European Union) that directly or indirectly collects the requisite fees from its members to underwrite international public goods (IPGs).

To understand the role of international institutions in promoting IPGs, one must ascertain the nature of the good and whether it requires a push, a coax, or no assistance from a supranational structure or influential nation(s) and agents (such as charitable foundations).

The transnational community should explicitly direct scarce resources only to those global and international public goods that need either a significant push or only a smaller coax by the transnational community. When clubs or markets can finance international public goods, the community should sit back and let incentives guide the actions of sovereign nations.

This paper—a product of the Economic Policy and Prospects Group—is part of a larger effort in the group to analyze the financing requirements for international public goods. Copies of the paper are available free from the World Bank, 1818 H Street, NW, Washington, DC 20433. Please contact Sydnella Kpundeh, room MC2-332, telephone 202-473-9591, fax 202-522-2578, email address skpundeh@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at tsandler@usc.edu. July 2001. (49 pages)

ON FINANCING GLOBAL AND INTERNATIONAL PUBLIC GOODS

by

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In recent years, the World Bank, the United Nations (UN), and other international organizations are coming to recognize the growing importance of international public goods (IPGs) to their missions.[1] IPGs possess benefits that spill over national borders so that benefits extend beyond the country of origin. Provision of these goods represents a novel rationale for foreign assistance that transcends country-based motives because the donor may also gain from the good's benefits (Ferroni, 2000; Jayaraman and Kanbur, 1999; Kanbur, Sandler, with Morrison, 1999; Sandler, 1997). Technology continues to provide new forms of public goods whose benefits cross political and generational boundaries.[2] When an IPG is purely public, payers and nonpayers receive its benefits, and one person's consumption does not necessarily reduce the benefits still available to others from the same unit of the good. In the extreme case of global public goods (GPGs), the good's benefits disperse worldwide and may include efforts to curb global warming, to reduce ozone-depleting chlorofluorocarbons (CFCs) emission, to map the human genetic code, or to preserve the earth's biodiversity. IPGs are associated with a wide range of activities involving the environment, security, financial stability, scientific discovery, health care, infrastructure, poverty reduction, culture preservation, and research and development.

Given this heightened interest in the study of IPGs and their allocative and distributional implications, a key concern is how to finance the provision of these IPGs. Should the world community rely on voluntary efforts to finance IPGs at the national level? Should it instead engineer a collective response? Or should it employ a combination of voluntary national provision and collective financing? The answers to these questions hinge on the nature of the public good.

It is essential to understand that the *three dimensions of publicness* – excludability of nonpayers, nonrivalry of benefits, and the manner in which contributions determine aggregate provision (i.e., the aggregation technology) – *influence the possibilities to finance IPGs*. The aggregation technology is a third dimension of publicness that goes beyond the two classical properties of nonrivalry and nonexcludability. As such, this third property proves instrumental in understanding policy recommendations (e.g., the use of taxes public provision in the presence of private provision) and institutional design (Bucholz and Konrad, 1995; Cornes, 1993; Sandler, 1997, 1998; Sandler and Sargent, 1995; Vicary, 1990). For some public goods, these properties are such that a public-sector "push" is needed or else the good will not be financed. This push can come in the form of a supranational structure (e.g., the World Bank, the UN, or the European Union (EU)) that collects the required fees from its members to underwrite the IPGs. The leader nation(s) might in some instances provide the required push and funding, which may only be germane initially, since voluntary financing may become adequate as nations gain experience with an IPG or develops a capacity or need for utilizing the good's benefits. Other IPGs' properties may promote market incentives or voluntary contributions so that only a little public-sector "coaxing" is necessary. For still other IPGs, incentives are consistent with the operation of markets or clubs, so that no official intervention is required as the IPGs are financed through nonofficial means with little transaction cost.

To understand the role of international institutions in promoting IPGs, one must ascertain the nature of the good and whether it requires a push, coax, or no assistance from a supranational structure or influential nation(s) and agents (e.g., charitable foundations). Resources are scarce in the international community and a reliance on markets and clubs, when feasible, will lessen burdens by channeling resources to those IPGs whose financing is the most problematic. At the

national level, governments support public good provision through taxes levied on its citizens, but a reliance on taxes imposed by a supranational government on subordinate nations is typically not an option.[3] Nevertheless, GPGs and IPGs are provided and underwritten either through charges levied by supranational organizations or clubs, or else through voluntary contributions. In many cases, the level of provision of IPGs will be inadequate given their far-ranging spillover of benefits. Alternative means and institutional arrangements for financing GPGs and IPGs are the topics of this paper. If the world community is to adequately support IPGs, then an understanding of these arrangements is absolutely essential. We inhabit a planet where, spawned by technology, novel IPGs appear often and present allocative challenges that must be addressed.

One purpose of this paper is to review some basic principles of public finance involving national and local public goods that can guide supranational financing of IPGs.[4] A second purpose is to relate these principles to a taxonomy of GPGs or IPGs that indicates the financing possibilities for each of five basic kinds of IPGs, distinguished by the nature of their benefits. A third purpose is to associate financing possibilities to the aggregation technology whereby individual contributions determine the overall level of the IPGs. A fourth purpose is to identify further considerations that can guide a society's quest for efficacious financial schemes. A final purpose is to show how these financing principles have been put into practice by a variety of supranational structures and other institutions in their provision of IPGs. Insofar as there are myriad public goods, each abiding by diverse financial considerations, there are many facets of this important question to explore.

BASIC TAXATION PRINCIPLES FOR FINANCING PUBLIC GOODS

It is instructive to consider some principles of taxation that apply to national provision of public goods when voluntary or private provision is inadequate. The public sector is involved with two essential activities: the provision of public goods and the redistribution of income to satisfy some ethical norm of fairness (Bruce, 1998). Although it is convenient to distinguish these activities, they are interrelated; thus, the manner in which a public good is provided has clear distributional consequences, while changes in an income distribution may itself be a public good. Two overall principles of taxation guide the financing of public goods at the national level and can be applied at the supranational level to IPGs.

The benefit principle requires that the recipients of a good's benefits pay their marginal willingness to pay (MWTP) or the value of their marginal benefit from consuming the good. If each consumer pays his or her MWTP, and if the *sum of the MWTP* collected *is equated to the public good's marginal cost of provision*, an optimal level of a *pure public good* is then provided, since social benefits match social costs at the margin. For *pure* public goods where benefits are nonrival and nonexcludable, agents do not willingly reveal their MWTP so that the benefit principle may prove impractical to implement. The failure of the provider to exclude nonpayers and to monitor use is what makes it exceedingly difficult to tie charges for pure public goods to the consumers' MWTP. If asked to reveal their MWTP, consumers are expected to understate their derived pleasure in an attempt to limit their payment for the good. A completely different situation characterizes a private good for which a person can only acquire the good by paying its market price. Agents purchase a private good until their MWTP, captured by the height of the points on their demand curve, equals the good's price. This price equals marginal cost under competitive provision, so that individuals automatically satisfy the benefit principle

through their voluntary purchases of private goods.

Most public goods are not purely public and permit either some exclusion or else some rivalry of benefits. If the public good's benefits can be withheld from nonpayers, then the private sector may be able to provide the good without public-sector intervention. Golf courses are both privately and publicly provided, and the same holds true for parks and schools. For a golf course, private provision is possible, because each round of golf can be monitored and a fee charged. Public provision and financing is best reserved for those situations where exclusion is inadequate and private provision is not feasible. For some activities, both private and public benefits are simultaneously derived; schooling benefits not only the individual with (private) marketable skills, but it also improves social well-being with enhanced demands for culture and/or law and order. If these private benefits are a sufficiently large share of total benefits, then private provision is possible as discussed in the next section. Private provision works best when the nature of the public good permits fees, collected from users, to be based on a benefit principle where aggregate MTWP is equated to the good's marginal cost of provision.

A second means for financing a public good when private alternatives are unavailable is to base the agents' financial burden for the good on their *ability to pay* in terms of their income or wealth. From an administrative viewpoint, an ability-to-pay scheme does not require the government to ascertain the agents' MWTP schedules, and, as such, is *not* expected to achieve an optimal provision of the public good. Efficiency is sacrificed for practical implementation. The actual relationship between ability to pay and assigned burdens reflects alternative notions of fairness. One such concept is horizontal equity, which requires people with the same income or wealth to carry identical burdens for the public good. Quite simply, equals should be treated equally. In the US tax system, the so-called marriage penalty is a clear violation of horizontal

equity. An alternative fairness criterion is vertical equity in which agents with higher incomes are made to finance a greater amount of the public good through taxes or assigned assessments. This criterion introduces distributional equity founded on an analogy with the utilitarian concept of diminishing marginal utility of income where a dollar taken from a richer agent has less of an impact on an agent's well-being than a dollar drawn from someone poorer.

Of these two equity criteria, vertical equity is more prevalent as a guiding influence for ability-to-pay schemes. Progressive income taxation, where richer people pay a larger percentage of their income in taxes than poorer individuals, is an instance of vertical equity. Membership dues to learned societies that are graduated based on income (e.g., dues in the American Economic Association and the American Political Science Association) preserve vertical equity where the shared public goods are the journals and infrastructure of the societies. The use of property taxes is another means of applying vertical equity by collecting more in taxes from those with greater wealth. I shall show below that vertical equity is also applied by some supranational structures, reliant on an ability-to-pay financing arrangement. When a push is needed, governments usually resort to an ability-to-pay arrangement that incorporates some criteria of fairness.

A TAXONOMY AND FINANCING POSSIBILITIES

There are various taxonomies for public goods in the literature depending on what purposes and properties of the goods are being studied (see, e.g., Sandler 1999; Kanbur, Sandler, with Morrison, 1999). In Table 1, five alternative categories of IPGs are distinguished according to how such goods fulfill the two properties of pure publicness.

Pure public goods

If the good's benefits are both nonrival and nonexcludable, then the good is a pure public good. A good's benefits are nonrival among users when one agent's consumption or use of the good does not detract, in the slightest, from the consumption opportunities still available to other agents from the same unit of the good. For example, reducing CFCs or greenhouse gas (GHG) emissions helps stem either the depletion of the ozone layer or else the heating of the atmosphere, respectively, that affects all nations. If a provider of a public good *cannot* keep an agent (e.g., an individual, a firm, or a nation) from receiving the good's benefits, then its benefits are nonexcludable. The provider cannot, therefore, keep a *nonpayer* from taking advantage of the good's benefit, and this inability limits incentives on the part of users to finance the good's provision. Again consider the reduction of CFCs and GHGs. Nations engaged in these reductions cannot deny other nations from receiving the benefits that result. Thus, curbing global warming and improving the protective stratospheric ozone shield are purely public, because both activities' benefits are nonrival and nonexcludable.

Two additional examples of pure public goods at the transnational level are limiting the spread of contagious diseases (e.g., AIDs and Ebola) and uncovering basic research findings. Efforts to forestall the spread of a contagious disease benefit all those at risk regardless of whether or not they supported the containment. Additionally, the reduced risk experienced by one person from prophylactic measures does not limit the safety afforded to others. Once made public, basic research findings will diffuse rapidly among those with the capacity to understand them. Even before being released, information about basic research findings tends to leak out to the scientific community. The findings are nonrival and can be exploited to advantage by countless teams of researchers without diminishing their benefits. For example, the discovery of

calculus gave a mathematical tool that can be used by one researcher without limiting its advantage of application to others.

In the two right-hand columns of Table 1, financing possibilities and remarks are given for each of the five categories of IPGs. Financing is most problematic for pure public goods. A best-case scenario would be a leader nation that derives sufficient benefits to justify its provision of the good even if the costs are solely borne by it. Efforts by the United States to underwrite the Centers for Disease Control (CDC) are such a case. In the absence of a leader nation, the global community will have to resort to a supranational structure (e.g., the UN) in which members are subsequently charged based on some ability-to-pay measure. Currently, there is no transnational public finance system where taxes collected on, say, internationally traded items (the so-called Tobin tax) could be earmarked to finance GPGs and IPGs, so that supranational structures must provide the required push to fund these goods.

With pure public goods, there is always a concern with "neutrality," where collective provision or financing crowds out voluntary national provision on a dollar-for-dollar basis (see Warr, 1983; Cornes and Sandler, 1996, Chapter 6). Thus, efforts to augment national provision with collective provision *will fail to increase overall public good supply if the voluntary contributors are made to fund the collective efforts*.[5] This neutrality or crowding-out problem arises because one contributor's provision of a pure public good is a *perfect substitute* for that from other contributors. Increased provision, no matter how it is financed, replaces the need to contribute on one's own. Neutrality has disturbing implications for financing a pure public good either through income redistribution from small providers to large providers, or tax-financed official support of IPGs with taxes levied on contributors. Neutrality indicates that engineered redistributions of income among contributors has no net impact on IPG supply; those receiving

income merely increase their IPG contributions by the amount that those losing income decrease their contributions. For purely public goods, contributors view public good benefit spillovers from others equivalently to extra income. To maintain their well-being, nations merely let the increased public good supply of others make up for their income losses stemming from taxes or redistribution. Only a tax imposed on a noncontributor can result in more of the public good but at the expense of social welfare if the noncontributor has little taste for the IPG. An efficiency loss arises because the tax burden on the noncontributor would outweigh any gain derived from the augmented IPG supply if the noncontributor has little desire for the good.

Another consideration has to do with partial cooperation whereby some nations choose not to be part of a collective agreement or supranational organization established to provide more of a pure IPG. These noncooperators can partly or wholly offset the increased contributions by deliberately contributing less in response to cooperation-induced increases in provision (Buchholz, Haslbeck, and Sandler, 1998). The success of partial cooperative financing of a purely public good is bolstered by three factors: (i) a large number of cooperating countries, (ii) noncooperators with a relatively low (high) valuation of the private (public) good, and (iii) a large proportion of noncooperators, which are minor contributors. Such factors provide little ability for the noncooperators, by cutting back on their support for the IPG, to undo the efforts of like-minded cooperators. Factor (i) implies that there are less noncooperators to counter efforts at cooperation, while factor (ii) indicates that noncooperators have little incentive to reduce their IPG provision in response to partial cooperation. Finally, factor (iii) means that only small cutbacks are possible since noncooperators are minor contributors prior to a cooperative arrangement, which does not include them. Such a partial agreement can finance the IPG through cost shares assigned to each country based on ability to pay, since there are no incentives

to truthfully reveal MWTP. Even with cost-sharing agreements to supply more of an IPG, an enforcement mechanism may be required and this presents yet an additional collective action concern as to how such a mechanism will be financed among the cooperators (Heckathorn, 1989).

Impure public goods

When IPGs possess benefits that are either partially nonrival or partially excludable (i.e., excludable at a cost), they are *impurely public*. The second category of public goods in Table 1 consists of impure IPGs that display some rivalry but whose benefits are still nonexcludable. Such goods include ocean fisheries where property rights may be difficult to protect or else are owned in common, so that benefits still have a strong element of nonexcludability. Rivalry applies because increased fishing efforts limit the catch of others through crowding. That is, each fishing vessel must exert greater effort to haul in the same catch as the efforts of others increase. Controlling pests, curbing organized crime, and alleviating acid rain display rivalry as efforts by one individual influence benefits available for others. For pests, control applied in one place cannot also be applied elsewhere and results in the pest population decreasing where the action is taken and increasing where it is not. Efforts directed to thwarting organized crime in one place may merely displace the criminal activity to a less protected venue so that benefits are rival through the consumption process. Improvements to the environment or to security within a society stemming from these activities are, however, nonexcludable. Without excludability, this class of goods may at times be difficult to support through voluntary actions, so that either some push is needed from a supranational organization or else a leader nation is required. Rivalry, however, limits neutrality since contributions are less substitutable and there may even result, for

some cases, sufficient private inducements to promote contributions. If, for example, a nation's efforts to control sulfur emissions primarily curtail acid rain over its own territory, owing to a spatial rivalry (i.e., every ton of emissions dropped on it cannot fall elsewhere), then some voluntary action can be anticipated (Murdoch, Sandler, and Sargent, 1997).

The remaining three categories of IPGs in Table 1 all have better prognosis for financing without the need for some elaborate supranational structure, owing either to excludable benefits or else private nation-specific gains. For these three cases, either a coax or no help is needed from a transnational public sector. In the middle of Table 1, impure IPGs *with some excludable* benefits are listed. Provision of these goods — e.g., a missile defense system, disaster relief aid, extension services, and information dissemination — can be withheld from nonpayers. Thus, whether or not a country is protected by a missile defense system or whether it receives extension services hinges on its own provision or its willingness to pay a provider for these excludable benefits. Exclusion promotes voluntary financing and club-like structures where use can be monitored and charged a fee. Because exclusion is not complete, some suboptimality remains. Consider information dissemination where it may be difficult to control whether or not one buyer can freely pass on the acquired information to a nonpayer. Even for missile defenses, protection may not be denied to a nonpayer when collateral damage to the provider would result from an attack on the nonpayer. An ideal club arrangement charges a toll to internalize the crowding externality associated with rivalry,[6] but for this third kind of IPG there may not be rivalry and this presents a problem — e.g., possession of information by one nation need not result in rivalry for another if the information can be provided easily whenever needed.

Club goods

Club goods represent the fourth kind of IPG and holds out the greatest promise for self-financing without an elaborate structure or guidance from a supranational governmental body. If exclusion cost is sufficiently small to allow utilization rates to be monitored and users to be charged a *toll* or user fee, then the users can form a club and provide themselves with the shared good. Nonmembers are excluded from the benefits of the club good, while members pay a toll for each use or visit equal to the marginal crowding cost that results. In this way, the toll internalizes the crowding externality and resources are directed to their most valued use.

A member visits the club and pays the user fee only when the member's resulting gain is at least as great as the toll that must be paid per visit. Even taste differences among members are taken into account – members with a stronger preference for the club good will visit more often and will thus pay more in total tolls, so that preferences are automatically revealed. As such, *club members are charged their MWTP and, hence, club pricing abides by a benefit principle.* For clubs to function properly, there must be an exclusion device that is inexpensive to operate and there must also be crowding or rivalry in consumption that requires internalizing. If the scale of the club is insufficient to accommodate all nations, then multiple clubs can be replicated so that every nation finds itself in an optimal-sized club (Sandler and Tschirhart, 1997).[7]

Clubs provide an institutional alternative to the creation of elaborate supranational structures or taxing authorities. Given the way that nations cherish their sovereignty, they are loathe to agree to such supranational taxation as a means of financing IPGs. Clubs are relatively simple structures that require little more than an exclusion mechanism or a toll booth so that transaction cost is economized. Once income or sales taxes are used to finance IPGs, the link between who receives the goods' benefits and who finances them is severed, so that allocative

inefficiency results. Through their toll charges, clubs maintain this connection between benefits and financing, because only those members whose MWTP justifies paying the toll will use the facilities, and then only to the point at which a member's MWTP just equals the toll.

Full financing of optimal provision of the club good depends on congestion, production, and competitive considerations. The form of the crowding function is an important determinant in ascertaining whether or not the toll can fully finance the club good (Cornes and Sandler, 1996, pp. 391-393; DeSerpa, 1978; Oakland, 1972). If the crowding function is homogeneous of degree zero in provision and utilization, so that a doubling of use *and* facility size leaves crowding unchanged, then an optimal toll will self-finance the club whenever competitive conditions prevail and production of the club good is *not under increasing returns to scale.* This follows because a toll set equal to marginal crowding cost associated with a visit takes in enough on each unit of the shared good to finance the marginal cost of provision (Siqueira and Sandler, 2001; Small, 1999).[8] If constant cost prevails, then the cost per unit equals marginal cost, and the proceeds collected on each unit also covers average cost. The tolls derived from all units provided will then just cover total provision cost. When increasing cost or decreasing returns to scale apply, marginal cost exceeds average cost, and a toll that earns enough to cover the former will more than finance the shared good. If, however, increasing returns to scale characterize the production of the public good, then a per-unit toll that finances marginal cost is insufficient to cover average cost. A two-part toll is then required with the shortfall in financing being made up by a fixed membership charge.

When competitive factor markets do not hold, there may exist monopsony in the buying of inputs, which implies a rising factor-supply curve (Small, 1999). For an IPG such as peacekeeping or peace enforcement, there may be monopsony elements for some factors such as

titanium used in weapon systems for strength. Such a noncompetitive consideration results in a toll that overfinances provision as the rising factor-supply curve diminishes economies of scale of cost thus leading the ratio of average to marginal cost to be less than one. If the toll per unit covers marginal cost, it will then cover average cost.

In the fourth row of cells in Table 1, four examples of club IPGs are listed. Transnational parks include the Great Barrier Reef off the coast of Queensland, Australia, as well as tracts of pristine rain forests worldwide. Even national parks qualify as transnational because of their international visitors. Toll schemes are used for these parks as a means for financing land acquisition, park infrastructure, and park maintenance – i.e., park provision and maintenance. INTELSAT, a private consortium of nations and firms as members, operates as a club to share a communication satellite network in geostationary orbit that carries most international phone calls and television transmissions. Data from remote-sensing satellites — e.g., LANDSAT surveying — are sold to users in a club-like arrangement based on individual demands for surveys. Canals and waterways — the Suez Canal and the St. Lawrence Seaway — permit exclusion and monitoring, thus representing club IPGs.

Joint products

The final category of IPGs, listed in the bottom row of Table 1, consists of *joint products* for which activities simultaneously yield two or more outputs that may vary in their degree of publicness. Joint products may be purely public, impurely public, or private. As nation-specific private and club good benefits become a greater share of the joint products, market and club arrangements can be applied to finance the activity, thus eliminating the need for any push or coaxing from some governmental body. Suppose that only nation-specific benefits characterize

the joint products. Recipient nations have a clear incentive to reveal their MWTP through payments for the IPG. Quite simply, nation-specific benefits, which are private among nations though possibly public within recipient nations, serve a privatizing influence, not unlike the establishment of property rights. Next suppose that both a nation-specific private benefit and a global pure public benefit are produced jointly by the public activity. If these jointly produced outputs are complementary so that nations desire to consume them together, then markets can sell the activity as a package based on a benefit principle applied to the private good component and use the proceeds to finance the entire activity. If club outputs are prevalent, then these can be charged tolls (Sandler, 1977). The essential determinant for financing joint products is the *ratio of excludable benefits* (i.e., nation-specific and club benefits) *to total benefits*. As this ratio approaches one so that all benefits are excludable, markets and clubs can be employed to finance the activity without elaborate and costly supranational structures. The closer the ratio is to one, the more relevant is a benefit principle of financing.

In many ways, joint products may include all of the other categories as special cases. If, for example, an activity yields only a single excludable and rival output, then it is a private good; if, however, it yields only a purely public output, then it is a pure public good. When an activity provides *both* private and public goods, it is neither purely private or public, so that a new category of goods is needed. This new class is called joint products. In practice, many activities give rise to multiple outputs, which vary in their degree of publicness.

Four cases of joint product IPGs are listed in Table 1. For example, poverty reduction in the form of foreign assistance can provide donor-specific benefits if the aid is tied or conditional. Additionally, any poverty that this aid relieves yields a GPG for all richer countries concerned with the well-being of those less fortunate. Even without conditional aid, a donor can derive

benefits from an IPG's output that protects its citizens, as in the case of containing an epidemic abroad with the aim of eliminating it before it arrives on the donor's own soil. Joint products also characterize the rain forests, whose preservation generates purely public benefits worldwide owing to carbon sequestration and biodiversity. Host-country and regional benefits from these rain forests include erosion control, localized climate effects, watersheds, and ecotourist sites. Such localized benefits provide these tropical countries with a stake or ownership in their forest preservation and, in so doing, should motivate some action. Peacekeeping provides nation-specific benefits for nations nearest to an instability, and also yields more global pure public benefits to the world community in terms of enhanced political security, reduced trade disruptions, and the curtailment of human suffering. Migrations and other collateral effects may impact nations near areas of conflict. Defense shared among allies provides pure public benefits by deterring an attack and nation-specific benefits from arms devoted to curbing domestic terrorism or maintaining colonial control.

AGGREGATION TECHNOLOGIES OF PUBLIC SUPPLY

To address the possibilities of public good financing, one must consider more than just the nonrivalry and nonexcludability of benefits. A third essential characteristic of publicness involves the manner in which individual contributions to the public good determine the total quantity of the good available for consumption. This relationship between individual contributions and the aggregate quantity of the public good is henceforth called the *aggregation technology*.[9] This aggregation concept influences the incentives that the potential contributors possess and, in so doing, affects financing and other policy concerns related to the provision of public goods. Although there are a rich variety of alternative aggregation technologies, only four

are discussed.[10] Table 2 indicates four alternative aggregation technologies, examples of each, strategic considerations, and institutional implications.

Summation

The most common technology is that of summation where each unit contributed to the public good *adds identically and in a cumulative manner* to the level of the good available to all for consumption. Since each unit has the same marginal impact on total provision, one agent's contribution is a perfect substitute for that of another agent. In Table 2, three examples of a summation technology are given in the top row. In the case of ambient air pollution such as methane from agriculture and mining, the total emissions in the atmosphere equal the sum of the pollutants emitted by various sources. Air quality is cumulatively affected by individual emissions. Similarly, efforts to improve air quality by reducing methane emissions correspond to the sum of individual cutbacks. The accumulation of greenhouse gases (GHGs) also abides by an additive technology of aggregation. If each of 1000 nations emits 500 metric tons of GHGs into the atmosphere, then 500,000 metric tons result and this accumulation heats the atmosphere. Each metric ton adds identically to global warming. When species are catalogued, each species identified adds a new single entry to the total.

When a classic public good problem is considered, often there is an implicit assumption that a summation technology applies. This technology was so ingrained in public goods thinking that, not until Hirshleifer's contribution in 1983, were other aggregation possibilities and their strategic implications even considered. Two game forms typically underlie the summation representation of a public good. First, there is the Prisoner's Dilemma where each potential contributor has a dominant strategy (i.e., best no matter what the other contributors do) to free

ride on the contributions of others (Sandler, 1992). This follows because a contributor considers just the difference between the benefits and costs that he or she derives from a unit contributed – benefits conferred on others are ignored. Suppose that each unit of the public good provides *each* of five potential contributors with 6 in benefits at a cost of 8 to just the provider of the unit. Even though a unit gives 30 (= 6 × number of persons receiving benefits) in total benefits, a potential contributor will view the transaction as yielding −2 (= own benefit of 6 − own cost of 8) and opt *not* to contribute. If all potential participants view payoffs like this, then everyone will free ride and nothing will be contributed. To escape this dilemma for IPGs, one or more nations must gain sufficient benefits, beyond those of the average nation, to provide the public good. This may be the case when some contributors are richer and place greater value on the public good (Olson, 1965; Sandler, 1992). A second escape can come from an organized effort on behalf of a multilateral organization to collect the necessary funds to provide the public good.

Second, a chicken game can apply for a summation technology where per-unit cost is again less than per-unit benefit when viewed from an individual contributor's perspective. The difference in the chicken representation is that doing nothing at all, or doing too little, results in negative payoffs – i.e., some of the public good *must* be provided or everyone suffers. Not contributing is no longer a dominant strategy. If, for instance, nothing at all is done about a pollution problem, the consequences may be dire. The same may be the case for an emerging plague. Now there are incentives for one or more nations to accomplish some minimal sufficient effort to forestall the disaster. The most likely contributor(s) is (are) the best endowed nation(s) or else some multilateral agency that can direct efforts.

A summation technology, when combined with nonrival and nonexcludable benefits, results in financing worries for IPGs and the need for transnational public-sector coordination.

Weakest-link

For a weakest-link technology, the smallest contribution level fixes the quantity of the public good for the entire group. When controlling a contagious disease, such as river blindness (onchocerciasis), a nation expending the least efforts at containment determines the risk to neighboring nations of the disease spreading by a parasitic worm carried by a black fly. In Hirshleifer's (1983) classic paper, the concept of weakest-link was illustrated by dikes along a circular island, for which flood protection hinged on the height of the lowest levee. Another example is the integrity of a network where the least reliable part determines the reliability of the entire network. When a nation is confronted with an insurrection, the province with the least effective defense sets the safety standard of the entire nation by allowing the rebels to gain a base from which to launch their attacks. Yet another example concerns tracking the progress of a disease or a pest where the monitoring station least up to the task determines the authority's ability to know the progress of the disease or pest. Currently, the United States is seriously contemplating improving the Russian early warning system, which is in disrepair, so that Russia never wrongly thinks that it is under attack.

Incentives are more favorable for the international community to supply and even finance other countries' weakest-link public goods owing to an inherent complementary. For such IPGs, incentives exist for each nation to match the smallest contribution because larger contributions use up scarce resources without augmenting the level of the IPG. An *assurance* game applies where it is in the interest of each nation to match one another's contributions to a weakest-link IPG because failing to do so makes it worse off (Sandler, 1992; Sandler and Sargent, 1995, p. 153).[11] Unlike the Prisoner's Dilemma, contracts are *self-enforcing* since once one nation

delivers its IPG provision, others can only prosper by doing the same. There is also an inducement for rich nations to form partnerships with poorer countries so as to raise their level of a weakest-link IPG to more acceptable standards (Ferroni, 2000; Vicary and Sandler, 2001). Ferroni correctly indicates that these partnerships are complex and difficult to achieve, but the incentives are nevertheless right for doing so. Moreover, it is an easy political sell to the rich country's constituency that foreign assistance to improve, say, the fight against an infectious disease provides safety at home. Partnerships to foster the financing of these weakest-link IPGs can be either bilateral or multilateral. Supranational organizations such as the World Health Organization (WHO) can *coordinate* such partnerships. Recognition of weakest-link IPGs provides a whole new rationale for foreign assistance. When a wealthy country has both funds and a comparative advantage in providing the IPG, it is best for it to provide such increases of a weakest-link IPG directly until the recipient builds up its own capacity (Buchholz and Konrad, 1995; Jayaraman and Kanbur, 1999; Vicary and Sandler, 2001). Over time, a recipient country's capacity to provide its own weakest-link IPG should be fostered. It is in the interest of donor countries to build up recipient countries' provision and financing capacity with respect to weakest-link IPGs. This is particularly true when a large number of countries have insufficient capacity.

Best-shot

"Best-shot" represents a third basic aggregation technology for which the *largest* contribution of an individual sets the aggregate level of the IPG available for consumption. When finding a cure for AIDS, malaria, or other diseases, the research team expending the largest effort is most apt to meet with the success that benefits everyone at risk. Once a cure is

uncovered, further efforts achieve very little or nothing. Similarly, engineering a successful neutralization of a pest through a clever strategy – for example, mating flies with sterile females released into the environment – eliminates the threat for everyone. Further research and other strategies are then unnecessary. A third example from Table 2 is the engineering of the next green revolution, which is likely to be discovered by the team with the greatest research budget and best scientists. In general, scientific and health breakthroughs abide by a best-shot aggregation technology.

The underlying game is that of *coordination* where just a single provider is needed and potential suppliers must decide amongst themselves which should expend the effort (Sandler and Sargent, 1995; Sandler, 1998). Coordination problems are particularly tricky when more than one best-shot candidate are present, because resources may be wasted if multiple efforts merely duplicate a discovery or fall short of those required to unlock the mystery. There are a number of institutional implications associated with best-shot (see Table 2). Supply efforts should be concentrated where the prospects and existing resources are the greatest for success. If potential contributors have equal likelihood of success, then multiple providers may make sense unless combining contributors' efforts augment this likelihood – a likely scenario with best-shot. With best-shot, there is a rationale for assisting the efforts of a rich nation, or forming a partnership among diverse participants. For a best-shot IPG in the health sector, partners might include drug companies, a host country, rich donor countries, and multilateral agencies. The prognosis is less optimistic when rich potential donors have less direct interest in a best-shot IPG. In the case of malaria, which is ravaging less-developed tropical countries, rich countries have displayed ennui since malaria poses little threat to their populations. Seeing little prospect for profit, drug companies have not until recently put much effort into finding a cure. Such best-shot IPGs that

do not involve rich countries need financing support from multilateral organizations such as the World Bank. Such goods do not possess the right incentives and thus the need for a public-sector push. Partnerships can also be spearheaded by such organizations, as in the case of Medicines for Malaria Venture discussed below.

Weighted sum

A fourth aggregate technology consists of weighted sum for which the weights in the sum are no longer one in value, as in the case of a summation technology. In fact, weighted sum generalizes the latter technology. Individual contributions possess weights, which reflect the marginal impact that a unit of a contributor's provision has for total provision of the IPG. For acid rain, the cleanup of sulfur emissions from power plants and vehicles adheres to weighted sum, as the location of the source of the pollutants makes a difference on the pattern of dispersion of downwind depositions owing to wind direction (Murdoch, Sandler, and Sargent, 1997). Countries further from the source of a cleanup receive smaller reductions in their acid rain deposits, as compared with a less distant downwind neighbor. Monitoring the planet at alternative vantage points yields aggregate intelligence, whose total is differentially impacted by the station's location. Efforts to control a pest may also adhere to weighted sum if the distribution of the pest is unequal, so that eradication efforts in its stronghold yield greater results than where the pest is less prevalent. With weighted sum, some nations receive *disproportionately greater benefits and thus possess a large incentive to support the IPG.* Efforts should be channeled to where provision has the greatest marginal impact.

A wide variety of game forms and strategic implications are associated with a weighted-sum technology. This follows in part because weighted sum can include summation (all weights

are 1) and private goods (the weight on the providing nation's provision is 1 and it is 0 on all other potential recipients). In the former case, Prisoner's Dilemma or chicken are relevant underlying games, while, in the latter, incentives exist for the country that benefits to supply its own private good. Depending on the weights, assurance or coordination interactions may apply where either matching behavior results or some dominant nation or group of nations provides the IPG. The greater the country-specific benefits derived from a weighted-sum IPG (i.e., the larger the weight on its provision), the greater its inducement to contribute. When weights are no longer 1, contributions are no longer substitutable, and there is no (neutrality) concern that public effort, coordinated by multilaterals, crowds out contributions from individual nations. Thus, some patterns of weights may promote IPG funding, thereby either limiting the required public-sector push or making such a push more effective when needed.

Multilaterals can further these self-financing incentives by providing the information required to compute the weights. This is precisely what the Cooperative Programme for Monitoring and Evaluation (EMEP) has done in Europe. Funded by the UN, EMEP has determined the weight matrix associated with sulfur emissions, nitrogen oxides, and other pollutants.

Thus, this third property of publicness has much to say about whether or not incentives are supportive of voluntary provision and financing of an IPG. When financing is unlikely, these technologies help define the role that a supranational structure or a nation's leadership can play in collecting the necessary financing.

TWO ADDITIONAL FINANCING CONSIDERATIONS

Economies of scope

In practice, many supranational structures address more than a single IPG allocation problem. For example, the World Bank not only gives out foreign assistance to alleviate poverty and promote development, but it also produces basic research. The United Nations promotes peacekeeping, alleviates hunger, tracks population growth, furthers world health, and facilitates environmental protection.[12] Even a military alliance like NATO pursues a host of public goods in addition to deterrence. These goods include traffic control, navigation, drug interdiction, and scientific research (Sandler and Hartley, 2001). Yet other supranational structures, such as the EU, International Monetary Fund (IMF), and the Organization for Economic Cooperation and Development (OECD), are observed supplying multiple public goods.

What factors are at work in such organizations that encourage them to provide more than one IPG? The answer involves economies of scope which occur when the cost of providing two or more IPGs jointly in the same institution is cheaper than supplying them in separate institutions. Such scope economies stem from *common cost* attributable to IPGs. If two IPGs can utilize the same administrative staff, communication network, meeting facilities, research staff, and scientific personnel, then there exists cost in common arising from shared inputs. Underutilized infrastructure may be the source of some economies of scope. As an infrastructure reaches full capacity, a supranational structure must decide if its cheaper to enlarge its capacity to accommodate additional IPGs, or whether it is more reasonable to assign new IPG decisions to either specialized institutions under its oversight or to independent institutions. Both practices are used. For example, the International Maritime Organization (IMO) and the International Telecommunication Union (ITU) are specialized UN agencies. In contrast, the World Court and the World Trade Organization evolved as a new institution; both institutions facilitate dispute

settlements over property rights and trade, respectively.

Subsidiarity

In a now-classic paper, Mancur Olson (1969) presented the concept of fiscal equivalence where those affected by the spillovers of a public good should be the ones who decide its allocation and financing. Quite simply, the decision-making jurisdiction should coincide with the region of spillovers so that only those who are affected get to express their preferences. "*Financing equivalence*" would dictate that the financial burden for the IPG should only impact those receiving its benefits. When the political jurisdiction exceeds the range of spillovers, taxes are then imposed on people (nations) that do not benefit, thus motivating oversupply by those making the decision. If, in contrast, the political jurisdiction is a proper subset of the IPG's range of spillovers, then the undersupply is anticipated as benefits conferred on those outside of the political jurisdiction are ignored. When, for example, an IPG benefits the people of three Eastern African countries, either these three nations or some regional organization specific to this area should address the good's allocation. In some cases, a regional network that connects nations confronting a common IPG issue needs to form as in the case of river blindness (see Table 3). Western African countries engineered a network among themselves to control both the parasite worm and the person-to-person contagion of the disease. Other partners, such as Merck and donors, were included to provide financing and to make the drug, Ivermectin, available to curb the spread of the disease (Ferroni, 2000, p. 17).

Subsidiarity not only places the problem on the most appropriate participants – those with the most at stake – but it also economizes on transaction cost. Focusing on the proper participants promotes allocative efficiency. The practice of subsidiarity involves a wide range of

IPGs. For peacekeeping, NATO's assumption of missions in Bosnia and Kosovo made more sense than the UN being in charge, since instability in those countries poses a greater threat to NATO allies than the world at large. Environmental treaties, such as the Helsinki Protocol curbing sulfur emissions in Europe, are best framed by the Europeans, which turned out to be the case.

Even many forms of foreign assistance involving IPGs can be improved by the subsidiarity principle where a cross-border spillover is handled by the agency whose geographical mandate is closest to the underlying IPG's range of spillovers. When the appropriate agency does not possess the requisite capacity, it is better to augment its capacity rather than to assign the problem to an organization with a larger geographical jurisdiction, unless economies of scale and scope warrant otherwise (Kanbur, Sandler, with Morrison, 1999).[13] To put this recommendation into practice, the World Bank would have to increase the capacity of a host of regional banks and, in so doing, would be limiting its own capabilities.

SUPRANATIONAL INSTITUTIONS AND THEIR FINANCING

Despite potential free-rider problems, a wide range of IPGs is provided within the international community by a variety of institutions. Some institutions provide the necessary push or the lighter coax needed, while others operate as clubs. By investigating how these institutions succeed in financing their IPGs, I am able to show that the properties of the good as well as other considerations discussed above play a role in the design of these institutions. Table 3 lists the institutions that I shall briefly examine, and it also gives a short institutional and financial description.

INTELSAT is an external communication network carrying the majority of transoceanic

messages. The system consists of 19 geostationary satellites positioned some 22,000 miles above the equator, from where the satellites orbit the earth in the same time interval that the earth rotates about its axis, thus leaving each satellite stationary over the earth. A mere three satellites are sufficient to provide point-to-multipoint service nearly anywhere on the planet. The other 16 satellites are used either to carry the volume of messages or serve as spares. Redundant backup satellites increase the system's reliability.

INTELSAT operates as a private consortium with firms, governments, and other institutions as members. Since coding and scrambling signals can restrict access to the network, INTELSAT qualifies as a club good. Utilization of the network can be finely monitored to the fraction of a second. As utilization of the communication system increases, the benefit per signal transmitted diminishes owing to congestion in the form of interference when more signals share the same frequency bandwidth. Members are charged user fees or tolls solely based on their per-unit utilization of the network; everyone pays the same toll per unit of transmission, but total payments differ according to a member's *total* utilization. Voting at meetings of the Board of Governors, the supreme decision-making body of INTELSAT, is weighted according to members' utilization rates and investment shares. Such a voting scheme promotes optimality insofar as heavier users serve more individuals whose MWTP must be aggregated, and thus have a greater stake in provision and other policy decisions. The financial design of INTELSAT is based on the benefit principle of equating the sum of MWTP to the marginal cost of provision through the use of tolls.

Although not listed in Table 3, LANDSAT also operates as a privately owned club that charges users for remote-sensing surveys of requested areas of the earth. Originally, LANDSAT was developed and funded by the US government for military purposes, but was subsequently

sold to private interests. A governmental boost was required owing to high R&D cost and the expense of lifting satellites into orbit. LANDSAT thus represents a case where a government provided the club with an initial provision and development push and then allowed the private sector to take over. Other international club goods include the Suez and Panama Canals, which charge tolls per transit. Internet providers constitute another instance of a club where members are charged for their use of the network, and proceeds fund increases in the providers' server capacity and reliability. Such increases help to limit congestion in the form of connecting and waiting time.

In Table 3, the second institutional arrangement concerns UN peacekeeping in which the UN carries out a variety of peacekeeping, peace enforcement (when the two sides do not agree to be separated), and humanitarian relief efforts.[14] Following the UN's first sizable operation in the Congo during 1960-64, it became apparent that UN resources would be stretched too thinly if such operations were funded from regular membership fees, as originally planned. Given the public nature of peacekeeping, early attempts to solicit voluntary contributions yielded little funding. To create a more permanent and reliable funding source, the UN General Assembly passed a resolution that established assessment accounts, beginning in 1975, for peacekeeping operations.

These assessment accounts distinguished four classes of payers: the five permanent members of the Security Council (A); twenty-two developed countries, not permanent members of the Council (B); wealthy developing countries (C); and poorer less-developed countries (D). Nations in class A and B finance the lion's share of peacekeeping operations, with permanent members of the Security Council paying 63% and developed nations in class B paying almost 35% on average. Thus, countries in class C and D underwrite just 2%. The five countries in

class A pay 22% more than their regular budget assessment *scale* to peacekeeping. Thus, the United States covers 25% of the UN regular budget, but it must fund approximately 31% of peacekeeping expenses. Group B nations pay their regular budget assessment scale, while Group C (D) countries pay just one-fifth (one-tenth) of their regular budget assessment scale. Assessed peacekeeping burdens are intended to be disproportionate in terms of income and, as such, display strong ability-to-pay equity considerations. Since nations within designated classes are treated identically, horizontal equity is also practiced.

Once a UN member is in arrears for its assessed amounts for two full preceding years, Article 19 of the UN Charter provides that the member can lose its voting privilege in the General Assembly. For class A members, this penalty is not as severe as losing its vote on the Security Council. Since Council members, and wealthy nations in general, have a greater interest in peacekeeping, the assessment accounts also apply the benefit principle to a small extent. It is, however, clear that the strong elements of nonrivalry, nonexcludability, and best-shot aggregation mean that a supranational institution is required to provide the push.

The next supranational institution, the United Nations, in Table 3 is one of the most complex and serves as the umbrella organization for smaller specialized agencies (e.g., WHO, IMO), which are financed through membership fees, donated trust funds, and UN support. The UN provides a host of GPGs and IPGs, financed through regular membership fees and voluntary contributions.[15] Numerous IPGs are supplied so as to take advantage of economies of scope stemming from common elements of the UN's massive infrastructure, which can economize on cost. Regular membership assessment is guided primarily by ability-to-pay considerations that stress less vertical equity than was true for peacekeeping assessment accounts. Assessment scales are altered periodically to adjust for member nations' changing economic fortunes in terms

of income. For example, Russia's membership assessment scale has been reduced since the breakup of the Soviet Union as the Russian economy shrunk, while Japan's assessment scale has been increased. In its role of supplying information, the UN charges for its print and electronic publications and, in so doing, uses exclusion of impure public goods as a means of establishing a market in information. Given the vast array of public goods supported by the UN and its subsidiary organizations, it is not surprising that a variety of financial instruments are used, guided by the goods' three dimensions of publicness. Supplemental support from regular membership fees or specific assessments is required to finance nonrival and nonexcludable benefits where user fees are not feasible.

NATO is a military alliance that shares deterrence coming from a collective threat of punishment to any state attacking the territory or interests of a member ally.[16] Established in 1949, NATO has grown from its 12 original allies to 19. Allies share a defense activity that yields joint products, which vary in their degree of publicness (Sandler and Hartley, 2001). An arsenal may deter aggression while allowing the provider to pursue its own territorial ambitions, where deterrence and imperialism are the joint products. An alliance can fulfill at least three general functions: (i) deterrence, (ii) damage limitation or protection, and (iii) private or ally-specific benefits. Deterrence is purely public among the allies and the most subject to free-riding concerns. In contrast, damage-limiting protection, needed when deterrence fails and war ensues, is subject to rivalry in the form of force thinning as a given contingent of forces is spread to defend a longer exposed border. Private or ally-specific benefits occur when a jointly produced defense output assists the provider, but the output's benefits are not available to others. Such private benefits include quelling domestic unrest, controlling domestic terrorism, responding to national disasters, or patrolling coastal waters.

As the *share of excludable to total defense benefits* increases, an alliance can rely on allies' independent behavior to spend where their benefits are the greatest. Sandler and Hartley (1999, 2001) argue that from the 1970s until the present day, a sizable portion of defense benefits is excludable, so that the benefit principle can be partly satisfied by independent spending decisions. In practice, NATO allies do make independent spending choices. Less than 1% of its allies' aggregate expenditures on defense is used to commonly fund NATO's civil structure, infrastructure, and integrated military command, so that over 99% is spent independently by the allies. Over the years as weapons technology, the strategic mission, membership composition, and threat have evolved, the mix of joint products and, thus, the ratio of excludable benefits have also changed. As these changes occur, financial arrangements need adjusting; as this ratio increases (decreases), there is less (more) of a need for explicit coordination among allies. Recent changes in NATO's strategic mission, which stress peacekeeping and nonproliferation of weapons of mass destruction, have decreased the ratio of excludable benefits – thus calling into question the wisdom of NATO's loose structure. NATO provision of multiple public goods, as mentioned earlier, indicates that it is exploiting economies of scope.

The mission of the WHO is the maintenance of world health, which has both country-specific and worldwide public benefits. WHO provides services to member governments in the form of expert guidance, practical projects, health manpower training, and health program coordination. By coordinating health programs internationally, the WHO aims to foster a network of transnational cooperation in health practices. Some purely public benefits are anticipated to arise from such a network, as intelligence on diseases and plagues are shared and best practices are disseminated. Clearly, country-specific benefits derive from projects and health manpower training, whereas some rivalry results from expert guidance as a fixed staff

must cover more countries. Given the presence of joint products, the WHO could be funded by a combination of user fees and fixed membership charges, with the former covering excludable benefits and the latter charging for the nonexcludable benefits. But in practice, the WHO is a specialized UN agency supported by membership fees based on ability to pay and donated trust funds earmarked for specific purposes.

In recent years, there have been a number of transnational environmental treaties to curb CFCs, sulfur, nitrogen oxides, and other pollutants (Sandler, 1997). Most treaties rely on the signers to fulfill pledged cutbacks. At the international level, the UN Environmental Program, supported by UN membership fees, supplies the minimal infrastructure in terms of making treaty text available and collecting signatures of ratifying countries. The UN through its (ability-to-pay) membership charge supports this purely public benefit. The Montreal Protocol on stratospheric ozone-depleting substances provides for a *multilateral trust fund* to assist developing countries acquire the technology to substitute more ozone-friendly substitutes. Not surprisingly, this fund for what amounts to a pure public good is provided by contributions on behalf of just the rich countries and is rather modest in size. Thus, an official push is needed and received from leader nations. For most treaties, significant country-specific benefits arising from either joint products or a weighted-sum technology induce ratifiers to finance their own cutbacks and, in so doing, respond to benefits received.

The EU was originally established to eliminate trade and nontrade barriers among members by pursuing the free flow of goods, services, people, and capital. In its trade creation role, the EU provides a pure IPG to its member states by increasing welfare through static and dynamic efficiency gains from enhanced specialization of labor and scale economies owing to the increased size of the market. Over the years, the EU has evolved from its common market

purpose and assumed the provision of additional public goods (e.g., security, traffic control, contract standardization, health standards, pollution cleanup, monetary union, and scientific discoveries). As such, the EU is another instance where multiple public goods are provided to exploit economies of scope. These IPGs vary in their characteristics – e.g., contract standardization represents a best-shot IPG abiding by a coordination game.

The EU is unique among supranational structure in the grandeur of its vision and design – ideally to create a United States of Europe. At least three features set EU apart: (i) the use of a value-added tax on EU exchanges, (ii) a Common Agricultural Policy (CAP), and (iii) efforts to redistribute income from rich to poor nations. These value-added taxes on consumption not only finance EU-provided public goods but they also underwrite efforts to redistribute income among member states. Infrastructure projects have been specifically placed in poorer members to provide public goods while giving such members an income transfer. Value-added consumption taxes are more in keeping with an ability-to-pay rather than a benefit principle of taxation. CAP has diverted trade, added to inefficiency, and caused significant redistributions within and among member countries to the farm population. EU's frequent crises illustrate that even nations with much in common resist sacrificing autonomy easily on monetary, fiscal, and tax policies.

The World Bank is a multilateral agency that provides IPGs in terms of development assistance, technical advice, and research findings. In addition, the Bank coordinates development assistance from a host of donors including nongovernmental organizations (NGOs), countries, and charitable foundations. Activities of the World Bank vary in their public characteristics and the presence of joint products. Some activities – unconditional poverty alleviation and basic research – are primarily purely public among members, while other activities – fostering environmental quality and limiting migration – are apt to have the greatest

impact on host and neighboring countries.

The World Bank is financed by member countries' subscriptions to its capital stock, used for loans and to support the Bank's activities. An important country-specific benefit is promoted by assigning a members' votes in the Bank based on the size of its subscription (World Bank, 1999). In 1999, the United States held over 16% of the votes on the Bank's policies owing to its generous subscription. So in return for carrying a greater burden of the World Bank financing, *a large subscriber gains greater autonomy* over the Bank's policy decisions and direction. This support-for-votes practice provides a significant member-specific inducement that helps circumvent the free-rider problem. The IMF implements a similar policy. Institutional design can provide joint products and promote incentives. This assignment of vote shares stand in stark contrast to a nation's single vote in the UN General Assembly regardless of the UN financial burden that a member carries.

In Table 3, the next two institutions – the International Maritime Organization (IMO) and the International Telecommunication Organization (ITU) – are specialized UN agencies that oversee international shipping and communication, respectively. Membership fees that nations willingly pay finance both the IMO and the ITU. International trade and communication networks must address a number of collective action issues of a weakest-link or best-shot nature – interoperability or interconnectedness, accidents and mishaps, jurisdictional rights, and competitive practices (Zacher with Sutton, 1996). For international shipping, the IMO institutes conventions on accidents and accident prevention, innocent passage, pollution, and other concerns. For telecommunications, the ITU establishes practices to curb signal interference and allocates the frequency bands of the electromagnetic spectrum to various specific purposes. The ITU also promotes the adoption of standardized equipment. A significant factor inducing nations

to join these international institutions and to submit to their regulations involves mutual self-interests in achieving the free flow of trade and communication among nations. Although nations must sacrifice some autonomy over commerce and communications by satisfying these regulations, the true loss of autonomy is modest, meaning that the gain from standardized practices does not have to be great to still provide each nation with a net gain over membership fees. Safety at sea and/or freedom from interference along the spectrum represents a weakest-link public good, whose outcome is determined by the least careful behavior of the participants. In general, the adoption of standards of behavior or safety conventions denotes a best-shot IPG and adheres to a coordination game structure, where it is in the interest of each nation to abide by the agreed-upon conventions and to pay membership fees to support the institutions creating such conventions. A nation that defects from a standard is significantly worse off if the others abide.

The final two examples in Table 3 – New Medicines for Malaria Venture (MMV) and Onchoceriasis Control Program (OCP) – represent joint public/private partnerships (Ferroni, 2000). MMV involves a partnership that includes WHO, World Bank, Rockefeller Foundation, the United States, and two associations of pharmaceutical companies. This MMV partnership is fused together to focus resources sufficiently to achieve best-shot IPGs of discovering new medicines. By forming this partnership, each participant is asked to make a rather modest donation to a team in contrast to what would be involved if a participant had to go it alone. In the case of OCP, the partnership concerns the provision of a weakest-link public good where incentives are right for the African governments to match one another's contributions. For both cases, partnerships can provide the necessary funding owing to the supportive incentive structure associated with the underlying IPG's aggregation technology.

Common themes and institutions

The design of these organizations illustrates some common themes that underscore the importance of the earlier theoretical discussion. First, if exclusion is feasible and utilization can be monitored, then private, nonofficial provision can be financed through a club arrangement. Second, when a public-sector push is required in the form of a supranational organization, multiple public goods are frequently provided owing to economies of scope. Many elaborate supranational institutions address a number of IPG problems. Third, when a push is required, supranational structures rely on ability-to-pay instruments to fund IPGs, and thus sacrifice efficiency for feasibility. Fourth, with joint products, more of a coax rather than a push is provided by the supranational structure as country-specific and club benefits motivate contributions. Such structures can remain "loose" with modest common financing and enforcement efforts – examples include NATO and environmental treaties. Fifth, if a push is required for weakest-link and best-shot IPGs, then a partnership among private and public participants may coalesce resources so that either a minimally acceptable level is supplied by all or the required threshold for success is achieved.

CONCLUDING REMARKS

Not all GPGs and IPGs are created equal. The three dimensions of these goods – nonrivalry of benefits, excludability possibilities, and aggregation technology – determine what kinds of institutions or transnational actions are required for their provision and financing. In fact, the international community is devising a rich array of institutional designs and responses to fund IPGs. For purely and impurely public goods where exclusion of nonpayers is not feasible, a real push is needed by the international community to provide these goods. A supranational

structure is then required to institute membership fees or taxes to underwrite the IPGs. For weakest-link and/or best-shot IPGs, partnerships among public and private institutions can either ensure that everyone meets acceptable levels of a weakest-link IPG or that sufficient resources are accumulated to support a best shot-shot IPG. When club goods are present, users can form private collectives and fully finance the shared good with congestion tolls under a variety of scenarios depending upon production considerations, the nature of crowding, and competitive conditions. For activities giving rise to joint products, only a little coaxing from the international community is necessary if a large share of country-specific benefits exists or is complementary to the jointly produced public benefits. The basic message is simple: financing does not pose insurmountable problems for many IPGs. As researchers gain a better appreciation for how the nature of IPGs differs, they will acquire insights about the proper actions to support IPGs. The transnational community should only explicitly direct scarce resources to those GPGs and IPGs that need a significant push or else a smaller coax by the transnational community. When clubs or markets can finance the IPGs, the community should sit back and let incentives guide the actions of sovereign nations.

FOOTNOTES

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1. The connection between IPGs and global contingencies confronting humankind is presented in two recent books: *Global Challenges* (Sandler, 1997) and *Global Public Goods* (Kaul, Grunberg, and Stern, 1999). Also see Sandler (1998) and Kanbur, Sandler, with Morrison (1999).

2. This arises as technological advances create goods whose benefits extend beyond the providing nation – e.g., hydrofluorocarbons (HFCs), which are new refrigerants without ozone-destroying side effects. Technology also increases digital-based communication and, thus, the spread of knowledge via optical cables and satellite linkages. This diffusion not only serves as an intermediate input for IPGs but also enhances the demand for these goods. Furthermore, digital technologies foster the universality of knowledge and, in some instances, assist in supporting a property-rights regime for IPGs' distribution.

3. An exception is the European Union, which has the power to collect tax revenues from member governments.

4. The issue of how the international community prioritizes among alternative IPGs is not addressed in this paper except to note that ideally this should hinge on the sum of the associated marginal willingness to pay (Cornes and Sandler, 1996, Chapter 6) and marginal cost of provision.

5. If neutrality applies, then collective provision can reduce private provision, and can result in no increase in the overall level of the public good. However, *neutrality does not result in a smaller* overall level of the public good.

6. On clubs and their toll arrangements, see Buchanan (1965), Cornes and Sandler (1996, Chapters 11-13), and Sandler and Tschirhart (1997).

7. Clubs involve at least two allocative choices: the provision level and the membership size. The choice of the toll fixes the membership size. These two decisions are interdependent and must be made simultaneously.

8. With a homogeneous of degree zero congestion function, any increase in crowding from further utilization just offsets the decrease in crowding from greater provision as utilization and provision increase proportionally (Cornes and Sandler, 1996, pp. 272-277, 391-393).

9. The first treatment of alternative aggregate technologies is by Hirshleifer (1983) who refers to them as the social composition function. Numerous aggregation technologies are analyzed in Arce M. and Sandler (2001), Cornes (1993), Sandler (1992), Sandler and Sargent (1995), Vicary (1994), and Vicary and Sandler (2001). In a foreign assistance context, Ferroni (2000), Jayaraman and Kanbur (1999), and Kanbur, Sandler, with Morrison (1999) address the importance of alternative aggregation technologies.

10. Other important aggregation technologies include better-shot, weaker-link, and threshold. For a threshold IPG, a minimal level must be provided before any benefits are received.

11. Assurance games are a special subclass of coordination games. On the strategic implications associated with weaker-link public goods, see Arce M. and Sandler (2001). For weaker-link public goods, the smallest contribution has the largest marginal influence on utility, followed by the second-smallest contribution, and so on. Also see Cornes (1993).

12. This aspect is coordinated by the United Nations Environmental Programs (UNEP), which also administers environmental treaties.

13. The existence of economies of scope clashes with an ideal notion of subsidiarity. A framework for subsidiarity that acknowledges economies of scale and economies of scope needs to be formulated.

14. See Sandler and Hartley (1999, Chapter 4; 2001) on UN peacekeeping and its financial arrangements.

15. Although voluntary contributions are a source of funding, such contributions represent a very small share of UN total financing.

16. Sandler and Hartley (1999, Chapter 2) provide an institutional description of NATO.

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Table 1. International Public Goods: Alternative Types and Financing Possibilities

Good Type	*Examples*	*Financing possibilities*	*Remarks*
Xpure public	X curbing global warming X basic research X limiting spread of disease X augmenting ozone shield	Usually must rely on some kind of public-sector push based on an ability-to-pay charge. Financing coordinated by a supranational organization using some international taxation or fee arrangement. A leader nation or nations might exist if sufficient net benefits can be derived.	There are neutrality worries since voluntary contributions will be crowded out by collective contributions. Partial cooperation faces free-riding offsets unless there is sufficient participation. Enforcement mechanism is necessary.
Ximpurely public with some rivalry but no exclusion	X ocean fisheries X controlling pests X curbing organized crime X alleviating acid rain	Must again rely on supranational organization and some international collection arrangement. Rivalry may motivate more independent behavior in contrast to purely public goods.	More private incentives to contribute. Rivalry lessens neutrality concerns, but a push from the public sector is still required.
Ximpurely public with some exclusion	X missile defense system X disaster relief aid X extension services X information dissemination	Exclusion promotes voluntary financing and club-like structures. For these goods, the public sector may be needed for coaxing and facilitating eventual private-sector provision. There may exist an entrepreneurial or leader nation to market the good.	Since exclusion is not complete, some suboptimality would remain. Question is whether this residual suboptimality warrants any intervention or official inducements.
Xclub good	X transnational parks X INTELSAT X remote-sensing services X canals, waterways	Charge each use according to crowding that results. Nonpayers are excluded. Toll per use is equal to marginal crowding costs so as to internalize the congestion externality. Taste differences can be reflected by tolls paid on total visits. Nations with a greater demand visit more often and pay more than those with a smaller demand.	Can result in an efficient outcome. Clubs limit transaction costs. Full financing is dependent on scale economies, the form of the congestion functions, and other considerations (e.g., competitiveness of factor or output markets). No public coaxing needed.
Xjoint products	X foreign aid X tropical forests X peacekeeping X defense spending among allies	As nation-specific private benefits and club good benefits become more prevalent among the joint products, markets and club arrangements can be used to finance the good with greater efficiency. As the share of excludable benefits increases, payments can be increasingly based on benefits received.	Ratio of excludable to total benefits is the essential consideration. As ratio approaches one, markets and clubs work more fully. Institutional arrangements can foster these excludable benefits.

Table 2. Alternative Aggregation Technologies of Public Supply

Supply technology	*Examples*	*Strategic considerations*	*Institutional implications*
• **summation**: public good level equals sum of individual contributions	• curbing air pollution • reducing global warming • cataloguing species	Characterized often by Prisoner's Dilemma or chicken game form. In the former, there are strong incentives to free ride and not contribute; in the latter, there is an incentive on behalf of the richest to inhibit dire consequences.	In an assistance context, there is a need for a multilateral organization or rich nation to assume leadership and to provide the public good. Cannot typically rely on voluntary action at the national level.
• **weakest-link**: only the smallest effort determines the public good level	• containing river blindness • maintaining the integrity of networks • limiting the spread of insurrections	Assurance games where matching behavior characterizes the equilibria. Actions and/or contracts are self-enforcing. Well-endowed players have an incentive to assist those less well-off.	Multilateral agencies can channel funds and direct actions to raise public good levels to acceptable standards. Capacity building required in poor countries. Rich countries may contribute the public good directly to increase levels in poorer countries. Partnerships apply.
• **best-shot**: only the largest effort determines the public good level	• finding a cure for AIDS • neutralizing a pest • engineering the next green revolution	Coordination games where only a single provider is required. Problem of identifying this agent if there are two or more candidates – this is where coordination is needed. For development concerns, problems arise when best-endowed nation derives little benefit from the action.	Put supply efforts where the prospects and resources are the greatest for success. Multilateral organizations or a leader nation can serve to coalesce and focus resources and efforts. Partnerships among various participants can circumvent collective action problems.
• **weighted sum**: each country's contribution can have a different additive impact	• cleanup of sulfur emissions • monitoring the planet from different vantages • controlling a pest	Weighted sum implies that some participants receive greater private benefits and thus have greater inducements to contribute. Captures pure public and private good representations as special cases. A host of alternative game forms.	Multilateral organizations need to support efforts among only those nations with less country-specific benefits. Collect and provide information on the weight matrix to encourage independent financing.

Table 3. Examples of Supranational Institutions and Their Financing Arrangement

Institution	*Institutional description*	*Financial arrangement*
XINTELSAT	An external communication satellite network with countries and firms as members of a consortium. Satellites positioned in geostationary space provide global communication.	Operates as a club with charges to members based on tolls taking account of congestion. Total tolls differ based on total utilization.
XUN Peacekeeping	Since 1975, countries are assessed shares to support each operation. Voting privilege in the General Assembly can be suspended for a nonpayer if assessments are too far in arrears.	Countries are distinguished by four categories based on ability to pay (horizontal and vertical equity) and benefit principle. Strong vertical equity considerations dominate.
XUnited Nations	The United Nations provides a host of GPGs and IPGs through its regular membership fees and members= voluntary contributions. These public goods differ according to exclusion, nonrivalry, and joint products. Economies of scope being exploited.	Financing is based on ability to pay with a strong emphasis on vertical equity and UN status. Less vertical equity than peacekeeping assessments. Voluntary contributions are small part of funding.
XNATO	An alliance established in 1949 which has grown from 12 to 19 allies. Article 5 indicates that an attack on one ally will be viewed as an attack on all allies. Mission has changed numerous times and now involves crisis management and nonproliferation of weapons of mass destruction. Multiple public goods provided to exploit economies of scope.	99.5% of allies= expenditures on defense are done independently, while only 0.5% are done commonly to maintain infrastructure, NATO civil structure, and NATO military command. Defense spending appears based on the benefit principle owing to high ratio of excludable benefits.
XWHO	Mission is to pursue the maintenance of world health. Part of the United Nations. Joint products are present.	Based on membership assessments and thus ability to pay. Also based on donated trust funds for specific purposes.
XEnvironmental treaties	Agreements to curb various pollutants including CFCs, sulfur, nitrogen oxides, and GHGs.	Montreal Protocol on CFCs relies on a multilateral fund with contributions based on ability to pay. Most treaties depend on members financing their own cutbacks based on the benefit principle.

Table 3. continue p. 2

Institution	*Institutional description*	*Financial arrangement*
XEuropean Union	Economic Union to eliminate trade and nontrade barriers among members. EU pursues the free movement of goods, services, people, and capital. Public good of trade creation within union and gains in efficiency (i.e., specialization of labor, economies of scale, and growth). A host of other public goods of varying purity and joint products (e.g., security, traffic control, contract conventions, and health standards). Also income redistribution practiced. Economies of scope are being exploited.	Value-added taxes on exchanges within the EU is used to finance public goods and infrastructure linking EU members. Taxation abides by ability to pay rather than benefit principle. Significant redistribution and inefficiency tied to the Common Agricultural Policy.
XWorld Bank	A multilateral agency providing development assistance, technical advice, and research findings. It also coordinates development assistance from other donors (e.g., nongovernmental organizations and bilateral donors). The Bank's activities vary in their degree of publicness and the presence of joint products. Alleviation of poverty with little or no conditionality has a large share of purely public benefits. The Bank's research outputs possess mostly purely public benefits.	Financing for the bank's activities come from member countries' subscriptions to the capital stock. Country-specific inducements for subscribing derive, in part, from its number of votes, which is based directly on its subscription. Larger subscribers obtain a greater number and, thus, share of votes on Bank's policies.
XInternational Maritime Organization (IMO)	For international shipping, IMO oversees international trade and institutes conventions on accidents and accident prevention, innocent passage, pollution, and other concerns.	IMO is a UN specialized agency financed through membership fees. Nations willing to sacrifice autonomy to achieve coordination and public good of safety that results.
XInternational Telecommunication Union (ITU)	ITU establishes practices to curb signal interference and allocates the frequency bands of electromagnetic spectrum to purposes and countries. Promotes adoption of standardized equipment.	ITU is a UN specialized agency financed through membership fees. In nations' interests to achieve cooperation.

Table 3. continue p. 3

Institution	*Institutional description*	*Financial arrangement*
XNew Medecines for Malaria Venture (MMV)	A joint public/private partnership to control malaria that involves WHO, World Bank, Rockefeller Foundation, the United States, International Federation of Pharmaceutical Manufacturers Association, and the Association of British Pharmaceutical Industries. Aim is to discover and develop new drugs for the treatment and prevention of malaria.	Funding comes from multilateral agencies, donor countries, nonprofits, foundations and NGOs. Some pharmaceutical firms will partner drug discovery projects by lending their expertise and facilities. MMV will approach industrial partners to manufacture and market newly discovered and effective drugs. High-risk activity of discovery being collectively funded by multilaterals and other donors. Pooling of efforts to achieve best-shot discovery.
XOnchoceriasis Control Program (OCP)	In operation in West Africa for over 25 years to control river blindness from a parasitic worm. Partners include multilaterals, Merck Corporation, African governments, local communities, bilateral donors, foundations, and NGOs. Exploit participants' comparative advantage.	Funding supplied by the various participants with Merck making Ivermectin available for free. Control of river blindness and its contagion is an example of a weakest-link public good.

Note: Source for MMV and OCP is Ferroni (2000, pp. 10, 17).

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