# WORKING PAPERS IN ECONOMICS

OPTIMAL MIX OF URBAN PUBLIC SERVICES
THE CASE OF THREE INDIAN CITIES

by

P. Ganguli and S. Nath

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## 1. Introduction

One of the major themes in urban public finance relates to preferences of citizen voters and the supply response of local governments to these preferences in an attempt to attain optimal provision of local public services. This issue has been discussed in the context of one of two models - residential location and representative democracy. Residential location model based on the Tiebout hypothesis (1956) posits that individuals choose their residential location in order to receive a particular tax-service package and in this process reveal their preferences for local public goods. Here the process of preference revelation is assumed to be spontaneous. In the second model, preferences are revealed by voting (Bowen, 1943; Downs, 1957). Voting can take either the form of a referendum for a single public good or voting for political representatives. Through the majority rule, preferences of the median voter are satisfied.

The median voter model of local fiscal choice, derived from the Hotelling theory of spatial competition (Hotelling, 1929), emphasises the vote of the resident voter and the election process. In practice, however, one may find that elected representatives, in an attempt to maximise their own welfare, might neglect voters and impose their own preferences. Imposition of decision-makers' preferences is spontaneous in a dominant-party regime and is made to work in coalitional forms through vote trading among elected representatives from different parties. Therefore, under such circumstances, the decision-making process may be constrained in providing an optimal mix of local public goods.

This paper suggests a two-stage voting process which may resolve conflicts arising at a local government level with regard to the provision of a range of public services. The analysis focuses on the identification of the mix of services that best reflects constituents' preferences and distinguishes between two kinds of local government inadequacies: underprovision due to paucity of funds and inefficiency due to an



inappropriate allocative process. The plan of the paper is as follows. In Sections 2 and 3 we describe our model of the allocative process through which funds are distributed over different local service provisions. In Section 4 we apply our measure of efficiency in allocations to survey data from three major cities in India and assess the evidence. Finally, Section 5 concludes.

## 2. The Model

Two stages of voting characterise our budgetary process which leads to the final allocation of funds over the range of services. In the first stage, the residents of a locality elect their representatives on the basis of majority voting. We stratify residents into three classes - rich, middle class and poor, using certain income norms which are discussed in the statistical outline. All income classes succeed in sending representatives - and we assume that each individual has a single peaked utility index and, thus, representatives reflect median preferences of their respective classes. In the second stage, the committee consisting of elected representatives and appointed city officials, i.e., the executive, deliberate over the actual allocation. Here the majority of voters' choice is assumed to be inoperative. The crucial assumption is that each agent attempts to assert his choice in the budget allocation and the municipality attempts to resolve the ensuing conflicts, assuming the role of an arbiter. Since the ultimate solution depends on the choices of the agents, we propose a coalitional bargaining solution to the conflict of interests.

The ideal or optimal point on the preference plan involves a mix of expenses and, by definition, no deviation from it will be favoured. In other words, once this ideal mix is obtained no agent would prefer less of any service, given the notional contributions of the other two classes. Similarly, each will not be willing to have more of the service due to the additional expenditure required. We assume, following Siegal (1956) and Basu (1980), the quasi cardinal utility index of degree one over the service plane.[1] That is, only the first order differences in utility are comparable. We also assume that all agents cooperate in the game.[2]

We make the following rules binding on the agents.

Rule 1 If the elected representatives come up with unanimous solutions, the executive is bound to accept it.

Rule 2 If a unanimous decision does not emerge, the executive has the veto power to effect any allocation.

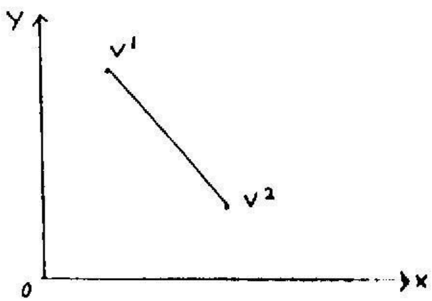
Rule 1 and Rule 2 imply that the executive has limited veto power.

Following Thomson (1985), we define a coalitional bargaining problem in the following way. Suppose, there are I agents and S is a subset of I. Then, S denotes a sub-coalition out of members belonging to S. Let V(S) be the Vector of payoffs to the members of subcoalition. We define V as the set valued function that translates every S E I into V(S). We define the coalitional bargaining problem as the tuple (I, V(S)).

In our model the function V is arrived at in the following way: A particular coalition S results in an agreement over a basket of services provided by the Urban Authority.

For the sake of diagrammatic exposition, consider a two-person, two-service game. The agents have ideal points $(X_1, Y_1)$ and $(X_2, Y_2)$ over the service plane (X,Y). Look at the following diagram: Let $V^1=(X_1,Y_1)$, $V^2=(X_2,Y_2)$.

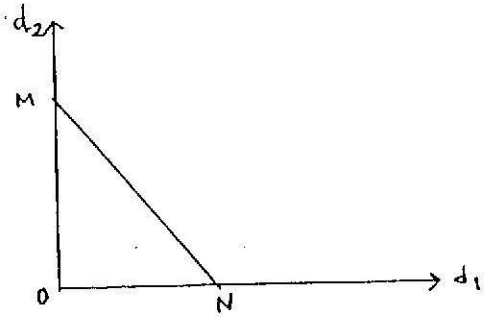
Diagram 1





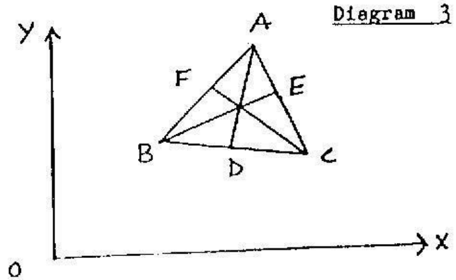

Any combination on $V^1 V^2$ is pareto efficient for the two-person coalition. When it is translated into a normalised utility plane, we get MN in diagram 2. M and N are respective 'ideal' points for Agent II and Agent I respectively and MN denotes the utility possibility frontier for the two-person coalition. The combinations of $d_1$ and $d_2$ along MN form the set V(2) in the utility space. Any combination of municipal services which the total local resource can fetch and has rankings in the agents' preference pattern such that the combination of utility is contained within MN, is pareto inefficient as at least one individual can be made better off keeping the status quo of the other by providing an alternative package of services.

Diagram 2




When three agents and many services are considered, the relevant utility possibility frontiers are depicted by a triangle ABC in the service plane (diagram 3). Each agent knows only his 'ideal' point, i.e., only one verti of the triangle. All the points within the triangular plane curved by the ideal points of the agents are pareto optimal. Such a triangle is available to the

Diagram 3



urban local body which acts as an arbiter and as a conduit of information. One the basis of the transmitted information, the agents behave in a particular fashion. A description of the conflicting preference patterns and resolution of the conflict are attempted in the following section in a game theoretic framework.

## 3. The Solution

Let us start off with agent I. His ideal point is A in Diagram 3. When the information of other two agents' ideal points reaches him, D becomes a potential perceived objection to A. As D is the mid-point of side BC, agent I perceives it as the common choice of other two agents if they form a coalition since D causes both the agents to lose equally from the coalition. If the coalition of agent II and agent III becomes successful in establishing D, then AD is the loss of utility of agent I. Thus, D is the package which agent I considers the worst, given his beliefs. The line joining A and D, i.e., the median line AD, is the offer line of agent I. Any point inside ABC, other than those on AD, are pareto inferior to agent I as he can always gain more by moving on to AD, keeping other two agents' welfare intact. The points A and D are the best and worst packages for him and any package on AD is pareto efficient. He believes that depending on the bargaining strengths of other agents' coalition, the final outcome will be somewhere on AD. Similarly, other agents' offer curves are given by the two median lines BE and CF.

When agent I is making a decision, he is concerned about a coalition between agent II and agent III which can bypass him and thus establish their own negotiated outcome. In that event, agent I loses AD level of utility from his ideal point. In such a case the urban local body fails to act as an arbiter of class conflict and conflict management is beyond its capacity. The emergence of such a situation would render agent I in the worst possible state. He assumes that agent II and agent III have identical bargaining strengths (which is an important assumption about the behaviour of the agents) and thus D is a potential threat to agent I's interest. So agent I's potential loss is AD. Similarly, agent II's potential loss is BE and agent III's potential loss is CF, if the opponents successfully form a coalition and the urban local body fails to curb it.



Let actual loss from the solution of the conflicts be denoted by $Y_i$ for the $i^{th}$ agent. And let us denote the potential loss of the $i^{th}$ agent as $X_1$. Any combination at which $Y_1/X_1$ are identical for all the agents is considered an optimal mix of expenses, as the combination makes an equiproportional sacrifice for the resolution of the crisis. Every agent is made to suffer in proportion of his worst state. Thus, relative well-being is equalised for all the agents. The rule which equalises the relative well-being is given by:

$$\frac{Y_1}{X_1} = \frac{Y_2}{X_2} = \frac{Y_3}{X_3} \qquad (1)$$

Since the goods in consideration are public goods, such an optimality is attained at G such that

$$\frac{Y_1}{X_1} = \frac{2}{3} = \frac{Y_2}{X_2} = \frac{2}{3} = \frac{Y_3}{X_3} = \frac{2}{3} \qquad (2)$$

From the properties of a triangle in diagram 3, the centre of gravity (centroid) of the triangle is the only equilibrium where AD, BE and CF intersect, i.e., at point G. Since AD, BE, CF are the medians of the triangle, the existence of G is ensured. G divides all the medians in 2:1 ratio. G is feasible and pareto efficient and satisfies conditions of individual and group rationality[4]. Further, the centre of gravity configuration is Von-neumman stable under a given set of conditions which defines the voting process. Hence, G is the solution of the game under these conditions.

Suppose the actual provision is x and the centre of gravity is G. Then the deviation, that is the Euclidean norm between the actual provision and G

$$d = |x-d|$$

offers a measure of the discrepancy between the actual mix of services and the optimal one as given by the centre of gravity solution. At the same time, d indicates the performance of the urban local body as an arbiter. The lower the deviation the more successful the urban local body as an arbiter of class conflict.

## 4. An Application

A. Data In an attempt to assess the actual allocation of local government resources in three Indian metropolis, both secondary and primary data was utilised. Secondary data on local government expenditure on different services was collected for the year 1980-81 from the CSO's Annual Statistical Abstract, West Bengal Municipal Finance Commission Report (1982) and the Urban Development Report No. 76-113 (The World Bank, Urban Public Finance In Developing Countries, a case study of Metropolitan Bombay). Primary data was collected through sample surveys conducted in the three metropolitan cities, namely, Bombay, Calcutta and New Delhi. From the sample surveys, we tried to capture the preference patterns of individual residents of a city over a number of services provided by the local body. We have chosen five services, namely water supply, street lighting, public health, road and buildings, maintenance. Interviewed subjects were requested to state preferences for the five services as per the rules laid down below:

Rule 1 Every subject is assigned a total of hundred votes which he is required to allot among the alternative services.

Rule 2 The stronger the preference for a service, the higher the number of allotted votes.

Rule 3 Maximum vote to any service is hundred.

Rule 4 Minimum vote to any service is zero.

Rule 5 The vote differences must indicate the intensity of preferences for the services.

Subjects were asked to state their present and past preferences, the latter related to a point of time five years earlier, so as to match the data on preference pattern with actual pattern of expenditures in the year 1980-81. The subject sample comprised 60 persons from each city representative of three broad income classes: high income, middle income and low income.



On the basis of rule of thumb and conferring with the municipal corporators, we arrived at the following loose income classification:

Classification on basis of Monthly Per Capita Income

(Rupees)

| City | Bombay | Calcutta | New Delhi |
|---|---|---|---|
| Income Group | | | |
| High | 1500+ | 1000+ | 1200+ |
| Middle | 800-<br>1450 | 700-<br>950 | 800-<br>1150 |
| Low | Below 800 | Below 700 | Below 800 |

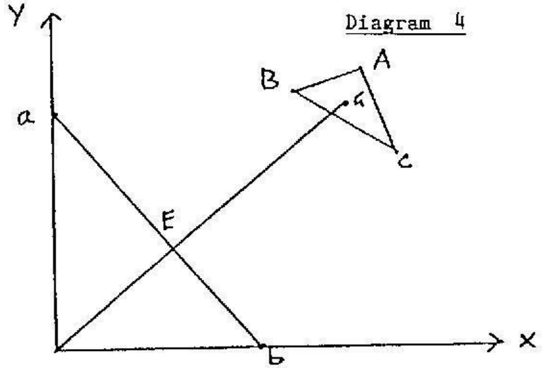
Thus, the survey results provided us with the data on preference patterns of representatives from a cross-section of the population for each city, ranging from extremely high to extremely low income classes.

### Results

The results are presented in tables 2 & 3. A comparison of the actual with our computed optimal mix of urban local services and values of deviation reveal considerable divergence. What is interesting is that the pattern of estimated "inefficiency" in funds allocation is found to be consistent across metropolis. Of the five services considered in this paper, health is accorded the highest priority in the centre of gravity solutions for Bombay and Calcutta. But in terms of actual allocation this service is relegated to the third position. In New Delhi actual allocation matches the optimal mix for health services. Maintenance is accorded the lowest priority in centre of gravity solutions in all the cities but the highest percentage of spending is allocated to this service in all the three metropolis. To understand the associated inefficiency in the service mix, consider the following hypothetical. Suppose the local government is providing only two services - public health (X) and maintenance (Y) and that the allocating committee comprises three members with ideal points on the issue plane A, B and C respectively.

For example, the first member of the committee has preferences captured by package A and will resist any deviation from it. Similarly for the other two with ideal points B and C. Our arbitration scheme implies a conflict resolution by opting for the point of gravity of triangle ABC, G, which is not dissimilar to the utopia point proposed by Kalai and Smorodinsby as a solution to the bargaining problem[5]. After normalisation (whose purpose is to force the disagreement point onto the origin), we draw the ray passing through G. The point of intersection between this ray and the Pareto budget line ab (E) corresponds to the optimal allocation of available funds given the committee's preferences and the actual tax contributions of residents represented by the slope of ab.

Diagram 4




Optimal expenditure levels on X and Y are given by G's coordinates whereas the optimal mix can be measured by the slope of ray OG. Provided decision makers allocate accordingly, the mix of public services will be optimal albeit its adequacy is not guaranteed. Whether the authority can afford to provide residents with an optimal mix depends on whether its funds are sufficient to ensure that the constraint ab can encompass solution G. If it cannot, then a second best solution is that at point E. Even though E is characterised by underprovision of demanded services, it maintains the optimality of the mix within the authority's budget constraint.

It is interesting to note that at least one member of the committee benefits from the authority's lack of funds. Suppose for instance that the second member with ideal point B is in minority within local government but has strong links with the national government. Would it not be a shrewd political move by this agent to encourage the national government to limit its funding of the local authority? If this is so, our model helps



illuminate the rationale behind some fairly sordid aspects of local government political manoevering To recap, deviation from E is considered as inefficiency in the mix. And the deviation of E from G measures the inefficiency in the level of provision of urban public services. Since Indian urban local governments face a severe resource crunch, it is highly unlikely that levels of such services will reach the optimum. Hence, there may be two types of inefficiency involved in the provision of urban local services - the level as well as the mix. This paper concentrates on the latter. In our survey individuals from different income classes were interviewed and it was made clear to them that their rates would not determine policy. If subjects thought they were actually voting then tactical voting would have clouded the results. However, since they were only expressing preferences their response is more likely to reveal true preferences than to have been influenced by strategic thinking.[6] Therefore the deviations of the actual from the optimal mix can be justifiably considered as an index of inefficiency. The three surveyed cities were ranked in terms of their efficiency of the adopted mix of urban public services according to our Euclidean norm. The result was that New Delhi led Bombay and Calcutta on the basis of our measure.

If we compare the actual provisions with the ideal points of different income class the following picture emerges. We define the maximum bias as the maximum deviation between actual allocation of a particular service and the 'ideal' allocation desired by a class. We, similarly define the minimum bias as the minimum deviation. We present the results in table 3. There we find that in Calcutta the maximum bias is against the poor for each service and the actual allocation is closest to the "ideal points" of the rich followed by the middle class. In Bombay the maximum biases against the poor are observed in water supply, street lighting and maintenance. But the poor get the benefit of minimum biases in terms of roads, buildings and public health. In Bombay the actual mix is closest to that of the rich followed by the middle income class and the poor.

In New Delhi the maximum biases against the poor are observed in terms of water supply, street lighting and maintenance. And the poor get the benefits of minimum biases in terms of roads, buildings and public health. The actual mix in New Delhi is closest to the middle income class, followed by the poor and the rich.

## Conclusion

In this paper we offer an alternative analysis to the residential location and representative democracy models for an explanation of local government responses to citizens' preferences. In contrast to Tiebout's (1956) hypothesis, which underpins the residential location model, the basic theme of this paper is that residents do not take the tax-service package as a datum but they participate in its formation.

Our model resolves conflicts of interest by means of a two-stage voting scheme. In the first stage we invoke the model of representative democracy to explain the election of representatives from different income classes to form the local government. In the second stage, these representatives interact to determine the service package. The resolution of conflicting interests resembles an arbitration procedure which homes in on the centre of gravity of the initial positions of representatives. Some interesting insights for the political motives of local authority representatives are revealed.

Lastly based on survey date and our theoretical results we assess the performance of the local authorities of New Delhi, Calcutta and Bombay in providing public services.



TABLE 1

Comparison of Actual with Optimal Provision

| Services | Actual allocation(%) | Allocation pattern of preferences (%) | | | Centre of gravity solution (%) |
|---|---|---|---|---|---|
| | | Poor | Middle | Rich | |
| **BOMBAY** | | | | | |
| Water supply | 14 | 32 | 16 | 21.5 | 23 |
| Street light | 20 | 10 | 17 | 15 | 14 |
| Public health | 14 | 25 | 25 | 26 | 25 |
| Roads & building | 14 | 17 | 24 | 21 | 21 |
| Maintenance | 38 | 16 | 18 | 16.5 | 17 |
| **CALCUTTA** | | | | | |
| Water supply | 30 | 20 | 28 | 18 | 22 |
| Street light | 7 | 18 | 14 | 16 | 16 |
| Public health | 10 | 26 | 27 | 22 | 25 |
| Road & building | 6 | 22 | 16 | 21 | 20 |
| Maintenance | 48 | 14 | 15 | 23 | 17 |
| **NEW DELHI** | | | | | |
| Water supply | 16 | 29 | 21 | 26 | 25.5 |
| Street light | 6 | 18 | 16 | 15 | 16.3 |
| Public health | 23 | 23 | 20 | 20 | 21.0 |
| Roads & building | 20 | 18 | 23 | 25 | 22.0 |
| Maintenance | 35 | 12 | 20 | 14 | 15.2 |

Source: Computed

TABLE 2

Divergence between Actual and Optimal Provisions
(Euclidean Norm)

| City | From the centre of gravity solution | from the preference patterns of | | |
|---|---|---|---|---|
| | | Poor | Middle | Rich |
| Bombay | 26.22 | 32.22 | 25.17 | 26.98 |
| Calcutta | 38.34 | 43.46 | 39.12 | 35.19 |
| New Delhi | 23.00 | 22.06 | 19.18 | 28.50 |

Source: Computed

TABLE 3

| Services | Bombay Min.Bias | Bombay Max.Bias | Calcutta Min.Bias | Calcutta Max.Bias | New Delhi Min.Bias | New Delhi Max.Bias |
|---|---|---|---|---|---|---|
| Water supply | M | P | M | P | M | P |
| Street lights | R | P | M | P | R | P |
| Public Health | P M | R | R | P R | P | R M |
| Roads & Buildings | P | M | M | P | P | R |
| Maintenance | M | P | R | P | M | P |

M = Middle Income class, P = Poor, R = Rich

Min. Bias = Minimum Bias, Max. Bias = Maximum Bias.

* Almost equal divergence or bias.



NOTES

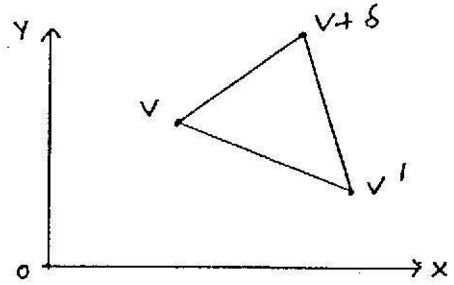
1. We define a metric d over (X,Y) which is assumed to be the two dimensional Euclidean space. Then the utility index is defined as d with the following condition I given the ideal point for agent 1 as $(x_1, y_1 = c_1)$.

i. For $V^1 = (X_1, Y_1)$ d $(V^1) = a_1 > 0$
For all $V^1 = (Y_1, Y_1)$ d $(V^1) = a_1 > 0$

ii. For $V^o = (X^o, Y^o)$, $d(V^o) = a_1 - (V^0 - V^1)$ for the ith agent.
When $(V^o - V^1)$ is the norm defined over the ordered metric space (X,Y).

iii. For all i, $d(V,V^1) < d(V+\delta, V^1) + d(V, V+\delta)$ for all real ordered pair $\delta$.
Condition (iii) is the well-known condition of triangular inequality and described in the following diagram:

Diagram 5




Condition (iii) states AC+BC> AB equality holding for $\delta = 0$.

2. Cooperating agents situation can be described in terms of either an assurance game or chicken game. Any game in which each player prefers to cooperate if others cooperate and to defect if others defect, is called an assurance game. A chicken game is one in which all the agents have the following preference ordering:

1. I defect, you cooperate
2. Let us both cooperate
3. I cooperate and you defect
4. Let us both defect.

Since one agent's defection may lead to the defection of all the others as the size of the pie is determined by their joint action, (2) may be the most preferred one when defection of one leads to choice (4). Thus all the agents cooperate instead of defecting.

3. Individual Rationality: Since, if agent I prefers to go it alone without entering into any negotiation then agent II and agent III arrive at D as the dispute resolving solution between them. So the minimum utility available to agent I is $(a_1\text{-AD})$ whereas the group solution given by the centre of gravity G provides him with $(a_1 - \text{AG})$ and definitely agent I is better off by entering into the coalitional bargaining.

For agent II the utility achievable if he goes all alone is $(a_2\text{-BE})$ and the centre of gravity solution provides him with a utility $(a_2\text{-BG})$ and thus it is rational for him to prefer G to E. For agent III the threshold utility level is $(a_3\text{-CG})$ and he prefers to cooperate to going by himself.

Group Rationality: Agent II and agent III are forming the coalition and thus unanimously declare D as the choice. Then D is pitted against A for further negotiation with agent I. Since agents II and III merge, the tussle is between D and A. The possible outcome is $AH^1$ when $H^1$ is the point at AD which divides AD into 1:1 ratio. Thus, the coalitional bargaining outcome at G provides higher utility levels to agent II and agent III if they form the smaller coalition since $BH^1 > BU$ and $CH^1 > CU$.

Thus G is group-rational for agent II and agent III. Similarly, we can show G is group rational for any tuple of agents. So the pay off configuration G is group-rational. Since any choice within the triangle is feasible and pareto efficient, G is feasible and pareto efficient. So G forms the core of the game. If agent II (say) wants



Agent I to be off, then he proposes, say. BS to agent III such that CS < CG. But to every sum S there is a counter-objection by agent I say, T which would definitely woo away Agent III as TC < CS and thus S is defeated. So G is a stable core as we always find the existence of a counter objection to any objection by any agent at the pay-off configuration G.

4. Computation of Centre of Gravity

Let $(X_1,Y_1)$, $(X_2,Y_2)$, $(X_3,Y_3)$ be the respective ideal points of agents I, II, and III respectively. The point D is given by the following coordinates:

$$D = [(\frac{1}{2} x_2 + \frac{1}{2} X_3),\ (\frac{1}{2} Y_2 + \frac{1}{2} Y_3)] = (X_4, Y_4)$$

G is the point which divides AD into 1:2 ratio when $A = (X_1, Y_1)$.

Let $\alpha = \frac{1}{3}\ (1 - \alpha) = \frac{2}{3}$

Then the coordinate of G is given by:

$$G = \alpha . A + (1 - \alpha) D$$

or $G = [(\alpha X_1, \alpha Y_1) + (1 - \alpha)(X_4, Y_4)]$

or $G = [(\alpha X_1 + (1-\alpha) X_4), (\alpha Y_1 + (1-\alpha) Y_4)]$

or $G = \alpha X_1 + (\frac{1-\alpha}{3}) X_4 = \frac{1}{3} X_1 + (\frac{1}{2} X_2 + \frac{1}{2} X_3) \frac{2}{3}$

or $G = \alpha X_1 + (1 - \alpha) X_4 = \frac{1}{3} (X_1 + X_2 + X_3)$

Similarly $\alpha Y_1 + (1-\alpha) Y_4 = Y_3 (Y_1 + Y_2 + Y_3)$

So G is given by the coordinate $[(\frac{1}{3}(X_1+X_2+X_3), \frac{1}{3}(Y_1+Y_2+Y_3)]$

5. Kalai-Smorodinsky solution: Let there be two individuals a, b and b who are bargaining and s the utility possibility set which assigns the utility payoffs to a and b from all feasible agreements. And let

d be the disagreement point that gives bargainers utility payoffs in the event of disagreement. We normalise bargainers' utility functions so that

$$d = (0,0)$$

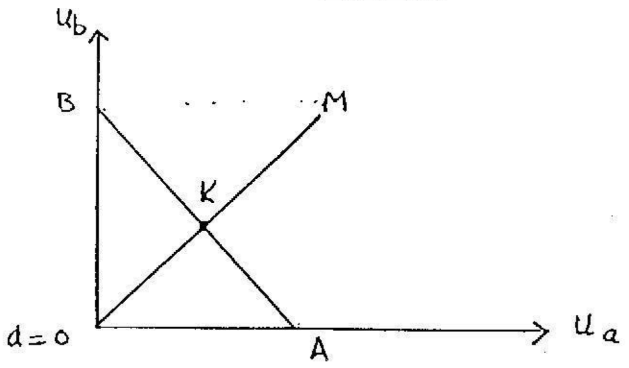
Let $U_a$ and $U_b$ be the utility payoffs to player a and b respectively.

Define $\underset{s \in S}{\text{maximum}}\ Y_a = A$ and $\underset{s \in S}{\text{maximum}}\ U_b = B$

The point M with coordinate (A,B) in the utility payoff space is defined as the "utopia point"

The line segment which joins M and d intersects the Pareto frontier AB at K. This point K is defined as the Kalai-smorodinsky solution.

Diagram 6




6. Strategic voting & Condorcet Paradox: Consider two individuals A and B with preference orderings over policies x,y and z as follows: {x,y,z}, {y,z,x}. Suppose also that in the event of a deadlock an unpire with preference ordering {z,x,y} has the casting vote. If the umpire asks A and B to reveal their preferences, then A and B will give different answers depending on their perception of the umpire's motivation. If they think that the umpire is asking them to vote for x,y and z, then tactical voting may impede an accurate revelation of



preferences. For instance, B may express a preference for z in order to block the worst outcome for himself (x) from emerging. Similarly, B may expect A to anticipate this and express a preference for y in order to forge a tacit alliance with B by voting for y which, after all, is what B wants most. And so on. Hence, if A and B believe that their response to the umpire's question will decide which policy will prevail, there is no reason to expect their responses to coincide with their true preferences. On the other hand, however, if they are convinved that they are participating in an opinion poll which will not affect policy (as the subjects of our survey were) then the perils of tactical voting are avoided.

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