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THE ANALYTIC HIERARCHY PROCESS AND THE VOTING SYSTEM

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Abstract: This article identifies the weakness of the traditional majority vote mechanism, and proposes an innovative voting method that is objective and takes each individual voter's sentiment into account. In particular, a decision maker is asked to express his/her intensity of preference for the issues encountered. Three hierarchical structures: benefits, costs, and risks are developed to evaluate the alternatives. It effectively applies pairwise comparison and synthesis techniques and can be used to solve many real world problems. Its implementation in a group decision making environment is also examined.

1. Introduction

Conventional wisdom regarding public policy development in a democracy is grounded in the widespread and essential majority vote mechanism. It is that either a simple or a two-thirds majority vote determines the final decision, and the minority must unconditionally compromise its position. It is a winner-take-all outcome. The losers' possible strong preferences for the opposite alternative are no longer important and their cooperation and deference to the will of the majority is expected. The vote drowns out the true merit of counter arguments. In principle and often in practice, opposing opinions are ignored and this may cause extreme pain to the losers. We wonder if this approach to democracy is ordained by God, by biology, or by human rationality, or if there is a better and more compelling way for making a decision.

Literature Review

Group decision making, and group preference derived from the inclination of individuals in the group have been the subject of great interest for nearly 200 years. In his scholarly book, Group Choice [1979], Boris Mirkin scans the diverse horizons of the field. Because the main focus of research in this domain has been on the ordinal representation of individual preferences, abundant literature has centered on the problems and on pitfalls of the ordinal approach. In 1961, Barbut constructed examples with voting on three alternatives to illustrate the paradoxes that arise from the ordinal approach. Several paradoxes are subsequently shown and culminate, and eventually lead to the well known Arrow's impossibility theorem [1963]. Basically the theorem says that, if the number of alternatives is greater than two, it is impossible to create a group preference ordering which satisfies the following four seemingly natural conditions that one would expect to hold:

a. No single individual determines the group order (*non dictatorship*).
b. The procedure must always produce a group order (*decisiveness*).
c. If every member of the group prefers alternative A to Alternative B, then the group must also prefer A to B (*Pareto optimality, agreement*).

d. The group choice between two alternatives must be based only on the individual preferences between this pair of alternatives (*independence of irrelevant alternatives*).

Three types of ordinal methods were attempted in the literature (preference scoring, distance based methods, and statistical methods) to remove the contradiction depicted by Arrow. They intended to relax one or the other of the four conditions, and in particular the fourth one (d). But that is not satisfactory, at least in addressing the question of the general uniqueness of the outcome regardless of the method used. Fishburn gives a lucid and precise account of these ideas in his two books [1973, 1987].

Cook and Kress [1985] develop a model for aggregating ordinal rankings in which the voter is allowed to express intensity of preference. They also propose a method to derive the consensus ranking. However, the story is still incomplete because the root of the impossibility lies in the use of ordinal preferences. The absence of a formal theory to enable one to aggregate cardinal preferences has been a stumbling block to go beyond the ordinal approach. Mackay [1980] writes that pursuing the cardinal approaches is like chasing what cannot be caught. Nevertheless, in 1971, Saaty by considering problems in arms control negotiations, developed a general theory of measurement based on ratio scales called the Analytical Hierarchy Process (AHP) [Saaty, 1982]. This theory provides a method for aggregating individual preferences into a unique group preference, hence removing the impossibility as proven by Srisoepardani in her dissertation [1996], guided by the first author. Owing to its measurement capability, AHP also facilitates group process to capture the strength of preferences of the individuals and incorporate them into the group preferences. The process works to ensure the validity of the outcome as it relates to the real world, a question rarely addressed in the ordinal approach.

This paper is intended to illustrate the use of the cardinal approach in group decision (voting) by emphasizing the point of aggregation. Numerous applications are being made of the AHP by practitioners, who use the team version of the AHP supporting software Expert Choice [1995].

2. Deficiency of The Traditional Voting System

Many in society regard the yes-no or (1-0) majority voting method as a law of nature mainly because so far we have not found a way of voting that is more practical and, more important, that is closer to the truth held by all the people and not just the majority. But, most people are not aware that the (1-0) head-count procedure has deficiencies. First, with a majority vote, individuals are unable to express their true preference for the subject of the debate without eventually taking the most extreme position by either voting for it or against it. A person may prefer one issue over its opposite only by a proportion of 51 to 49 percent. Yet, when that person votes, the vote is recorded as definitely for or definitely against, 1 being for and 0 being against. When many people vote with lukewarm feelings, the outcome indicates a stronger win than is justified by the reality. A small proportion of dominance by many votes should result in a slight preference for one option over another. Decision making under such circumstances is subject to extreme bias.

Second, issues of public concern may not be appropriate for resolution through the familiar process of competitive voting, whether the battle ground is the U.S. Congress, a state assembly, or a neighborhood debate. The real danger of basing decisions on the result of a head-count is that the win/lose dynamic is not good for cases where success depends on cooperation and team work in the legislatures, courts, administration, or in the private sector. The winner-take-all attitude may be appropriate for a society facing a war and seeking to win, but it is very out of fashion in situations where collaborative effort is essential for getting along. In a democratic society where there is a need to conciliate minorities, the current voting system is implacable and extreme. It may go against wide sentiment in the population.

A third flaw of the yes-no voting system is that the decision derived from a majority vote may give the opposite decision to what the collectivity wants. For example, let's define the preference intensity as the percentage of weight assigned to the relative importance of an alternative. If there are two people with intensities of preference of 45% for and 55% against an issue and one person with 90% for and 10% against the same issue, then **'against' wins** by a simple majority vote (2:1 ratio). Yet, if the intensities of preference are taken into account, the weight for the 'for' vote is (.45+.45+.90)/3=60% and 40% for the 'against', and **'for' wins** over 'against' - just the opposite of the yes-no vote.

A fourth difficulty arises in voting on several issues at the same time (agenda effects). When multiple issues are encountered, a vote is taken on each issue separately. If the issues are bound together (dependent) in some way, it can happen that an earlier issue that has bearing on what follows is voted out, killing the chance to successfully influence the others unless the older issue is reconsidered. The yes-no vote often prevents following a comprehensive view of issues as a whole and can lead to a chain of policies that are hard to carry out, or at best makes it less efficient to create what public sentiment is asking for. A better way can be a discussion of all the relevant issues with a simultaneous decision on them that ends up with a ranking of the issues.

Head count vs. intensity of preference

In this subsection, we detail the difference between the head-count method and the method of using intensity of preference in decision making. We consider a situation where there are four issues and 40 voters. By the head count method, the following voting would result in 'against' decision for issues 1 and 2, and 'for' decision for issues 3 and 4.

	Number of Voters		
# of Issue	Yes	No	**Majority Outcome**
1	19	21	No
2	10	30	No
3	23	17	Yes
4	22	18	Yes

A different approach would be for each individual voter to provide their estimates of relative importance across issues, and to determine the preference intensities of alternatives 'yes' over 'no' on each issue. Suppose each of the 40 voters are interviewed for an intensity of preference. The figures shown below are the averaged and normalized values so that the mean importance of all issues adds to one and the importance of alternatives (yes and no) on each issue also adds up to 1 (see below). The outcome of each yes-no pair (columns 3 and 4) multiplied by the relative importance of the issue to which they belong (column 2), results in global priority (column 5 and 6). Sorting the global priority in descending order, we found a ranked set of alternatives in the rightmost two columns. The alternative with the best rank for each issue is chosen (underlined). The decision based on this approach is issue #1-Yes, #2-No, #3-No, and, #4-Yes, which is very different from the 1-0 head count outcome obtained above.

	Mean Importance	Average Preference of 40 Voters		Global Priority		Overall Ranking	
# of Issue	of Issues	Yes	No	Yes	No	Yes	No
1	.30	.55	.45	.165	.135	2	4
2	.40	.38	.62	.152	.248	3	1
3	.10	.24	.76	.024	.076	8	7
4	.20	.61	.39	.122	.078	5	6

Here, we note that when various issues are deliberated concurrently, each alternative (yes or no) under an issue has different chances of success. The voter must specify intensities of preference for all issues and

alternatives, and form an ordered set of preferences. Under such conditions, one cannot exaggerate the percentages for one without making the others suffer. Since more than just a 1 or a 0 is needed, a decision maker is forced to think more about the strength of preference (s)he is asked to provide. Decision making becomes a more substantive and less a muddling through concern.

In section 4, we shall make use of this idea of deriving preference intensities and weighting them to examine its potential application to national issues. But first we discuss some current public affairs.

3. Current National Issues

The issues discussed and the observations made in this section are based on the views expressed by publications such as Business Week and Economist. Their statements form the basis for constructing the hierarchies and judgments in next section. The variables in the model and the numbers assigned are purely illustrative. Nevertheless, the idea we intend to convey is not undermined by this deficiency.

In today's society, many prefer smaller government, lower taxes, welfare reform, a balanced budget and less crime. When properly taken into account by lawmakers, these concerns would lead to new policies needed to reshape society. If mismanaged, they can increase racism, trade isolation and negativism, and drag a nation into recession. The challenge is to transform the power of the national sentiment into realistic, constructive policies that make the government more productive and less costly. To illustrate, we focus on the following three representative issues.

Welfare Reform

Many Americans want the welfare system to move people into the workforce and bring fairness to those who work hard, play by the rules, and respect the rights of others. In the short term, cash is needed to train the welfare recipient and provide care for the children. But, in the long run, welfare reform would motivate people to work, enhance worker's skills, and strengthen society's infrastructure. Reduction in health care and in social services appear to be an unkind attack on those who are less fortunate and are least able to fight for their needs. However, hardship is bound to take place, since it is estimated that Medicare, by continuing its current trend, will go bankrupt in the year of 2,003 and Social Security will face a similar fate in 2,020.

The Balanced-Budget Amendment

Spending cuts and welfare reform should be discussed in parallel. Everyone favors balancing the budget until (s)he discovers that entitlements (e.g. Social Security and Medicaid) would be jeopardized. To better serve the common interest, relevant issues need be deliberated concurrently.

Reducing defense spending may appear to be an attractive option for budget balance. However, deeper cuts in defense can endanger the role U.S. plays in foreign policy. In order not to unfairly shift financial burden to future generations, it is necessary that government takes action to balance the budget. Subsidy is another area of possible cut. When money is short, subsidizing education, arts and music shifts the economic burden to future generations and drive the country into long-term financial distress. Yet can we, for the sake of future generations, compromise our safety and security, lower our educational quality, and sabotage the environment? Where do we strike a balance?

Term Limits

Many regard term limits as a way to end a system that gives a few elite unlimited power. Opponents argue

that limiting terms limits citizens' rights to choose. It treats everyone - competent and incompetent - the same. It takes away the precious constitutional right of free choice.

It is advised that having an experienced Congress is like having an experienced doctor who is trustworthy when emergency occurs. Under term limits, representatives are inclined to overlook the need of the people they represent and pursue their own interest, since seeking long-term support from their district is not a major concern. A representative's myopic view as a result of a limited term can prevent him/her from looking out for his/her people's economic, political and social interests. The goal of eliminating the cozy relationship between legislators and special interest groups might not be realized by implementing term limits alone.

4. Applying the AHP to Voting

Research in the field of voting have well defined methods they use to investigate the subject and these methods have focused on the ordinal approach. They may believe that unless one or the other of their procedures is used, no valid result can be obtained. Yet in this section we innovatively apply the AHP to the well defined domain.

We take the aforementioned problems as relevant issues, and the set of political opinions assumed as the relative importance of issues and alternatives. We demonstrate the application of AHP to issues of national concern. It is important to point out that we do not claim our view of national issues to be self-evident truths, since these are extremely subjective matters; evidence and justifying argument are hard to come by, and a political consensus does not exist.

In addition to careful study and analysis when dealing with public affairs, legislators also use experiences and feelings; this kind of subjective judgments usually do not give due consideration to all important factors. The proposed AHP method evaluates the factors that influence the decision on issues in the framework of three hierarchies: one for the benefits of implementing certain policies, one for the costs and a third for the risks and uncertainties that can arise. Each hierarchy has a goal followed by the criteria that affect the performance of the goal. The issues are listed at the bottom level of the hierarchy.

Implementation in a group

One might question how to use AHP in an environment where a group of individuals must come up with a decision together. In group decision making, it is critical to aggregate the preference ranking of individuals into a consensus ranking. To arrive at an aggregate measure for the proposed method, each individual member in the group provides his/her final priorities (derived by his/her own AHP model) of the alternative issues. If there are n decision makers, their final priorities for each alternative are combined by taking the geometric mean which ensures that the reciprocal relation is satisfied. For example, if four committee members regard the relative importance of the welfare issue in the benefits hierarchy with the preference of 45%, 61%, 57% and 38%, then the aggregate importance of the welfare issue would be $(.45\times.61\times.57\times.38)^{1/4} = .494$. That is, individual judgment is replaced by the geometric mean for the group. It is easy to see that the reciprocal of this value is the same as that obtained by applying the geometric mean to the reciprocals of .45, .61, .57 and .38. It has been proved under fairly general conditions, that if one uses reciprocal judgment values, then the geometric mean is the unique way to apply to individual priorities to aggregate into the priorities of a group [Saaty, 1982].

In applying AHP to national issues, a decision maker first assesses the relative importance of the three issues under benefits, costs and risks hierarchy. The analysis would be followed by a determination as to whether

or not reform is needed. This is done by comparing the two alternatives - to change or not to change (maintain status quo) - with each other under each criterion in each hierarchy. Proportionality of the rankings - the three issues among themselves and the two alternatives within each issue - makes it possible to integrate all six alternatives into a single rank order under a hierarchy.

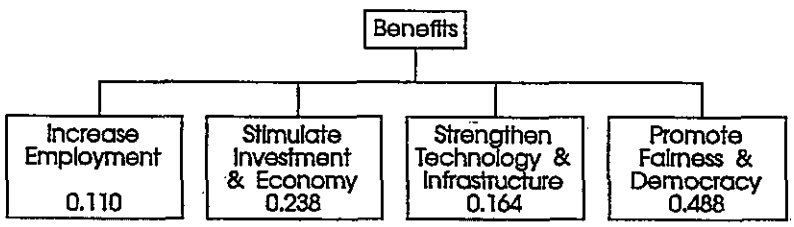
The importance (priority) of the issues indicate the relative commitment with which they would each be carried out if they must all be implemented. Our task is to determine which ones may not be implemented in an overall framework of benefits, costs, and risks relative to all the issues involved and not simply in isolation. Of course for each pair to change or to preserve the status quo, only one would be chosen. But which one is chosen is determined in the context of the overall priorities. We now describe how to apply the AHP method to voting in detail.

Determining the importance of each issue

Figure 1 displays the three hierarchies, one for benefits, the other for costs and the third for risks needed to assess the importance of each issue. The goal is at the top of each hierarchy, followed by the criteria that contribute to attain the goal. At the bottom of each hierarchy are the issues, whose priorities are to be determined.

The weights for the criteria in the second level of each hierarchy are derived by pairwise comparisons and synthesis as illustrated in the matrices of Figure 2(a), where each matrix specifies the judgments of the decision maker about the relative importance of each criterion in terms of its contribution to the achievement of the goal of that hierarchy. For example, in the Benefits hierarchy, a possible question is: How much more important is promoting fairness in society over the importance of stimulating employment in the public and private sectors? Assume it is believed that fairness is strongly of more serious concern, a higher priority value 5 is assigned to the former in the comparison. When a group of people are involved, each individual should provide his/her own judgement, their final judgements are combined by taking the geometric mean.

Figure 1. Three Hierarchies Needed for Assessing the Importance of Each Issue



Welfare Issue	.760	.682	.758	.625	.675
Legislator's Term Issue	.144	.103	.151	.136	.132
Budget Issue	.096	.216	.091	.238	.193

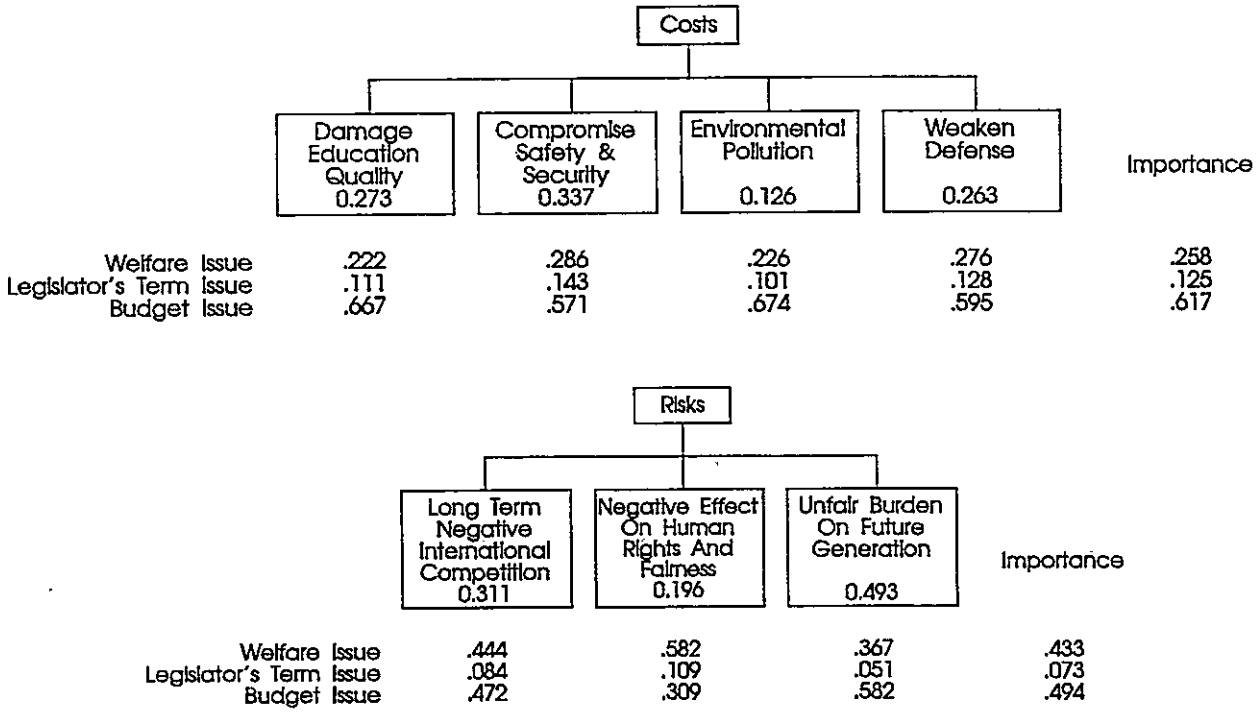


Figure 2. Deriving the Weights for Factors

(a) Pairwise Comparisons in Each Hierarchy

Benefits	Employment	Investment	Infrastructure	Fairness	Weight
Employment	1	1/3	1	1/5	.110
Investment	3	1	1	1/2	.238
Infrastructure	1	1	1	1/3	.164
Fairness	5	2	3	1	.488

Costs	Education	Safety	Environment	Defense	Weight
Education	1	1	2	1	.273
Safety	1	1	2	2	.337
Environment	1/2	1/2	1	1/3	.126
Defense	1	1/2	3	1	.263

Risks	Competition	Human Rights	Burden	Weight
Competition	1	2	1/2	.311
Human Rights	1/2	1	1/2	.196
Burden	1	2	1	.493

(b) Approximating the Weights of the Benefit Factors

Step 1: Sum the values in each column

Benefits	Employment	Investment	Infrastructure	Fairness
Employment	1	1/3	1	1/5
Investment	3	1	1	1/2
Infrastructure	1	1	1	1/3
Fairness	5	2	3	1
Column Sum	10	13/3	6	61/30

Step 2: Divide each element by its column sum.

Benefits	Employment	Investment	Infrastructure	Fairness
Employment	1/10	1/13	1/6	6/61
Investment	3/10	3/13	1/6	15/61
Infrastructure	1/10	3/13	1/6	10/61
Fairness	5/10	6/13	3/6	30/61

Step 3: Average the elements in each row.

Benefits	Employment	Investment	Infrastructure	Fairness	Weight
Employment	.100	.077	.167	.098	.110
Investment	.300	.231	.167	.246	.238
Infrastructure	.100	.231	.167	.164	.164
Fairness	.500	.462	.500	.492	.488

The exact mathematical procedure needed to determine the weight of each factor in AHP involves the computation of complex eigenvalues and eigenvectors. An easier but rough approximation is obtained by adding the numerical judgments in each column of the matrix, divided by its total, and averaging each row. This is the method adopted by AHP software Expert Choice. Figure 2(b) illustrates the procedure of deriving an approximation of the priorities for benefits hierarchy. The same approach is used to find the priorities of other criteria. The priority of each criterion is then transcribed from Fig. 2(a) to the second level of each hierarchy in Figure 1.

We now proceed to the third level of the hierarchy in Figure 1. The importance of each issue (welfare, legislator's term, and budget) as to how it contributes to each criterion is assessed. The pairwise comparison under each hierarchy and criterion are detailed in Figure 3. As an example, in the employment matrix under the benefits hierarchy, the welfare issue is considered to be very strongly more important in contributing to increase employment over the legislator's term issue and therefore the former is given the value 7 when compared with the latter. The three issues are compared with respect to their contributions to each criterion. Relative importance is given at the right of each matrix.

Next, we post all the scales to Figure 1, weight the importance of an issue by the priority of its parent criterion, and add to obtain the overall importance of that issue (the rightmost column). For example, the importance of the welfare issue in the benefits hierarchy is .675, which is found by:

$$.760 \times .110 + .682 \times .238 + .758 \times .164 + .625 \times .488 = .675$$

Note, in AHP the benefits hierarchy determines which issue yields the greatest benefits with respect to each criterion; the costs hierarchy discovers which issue is most costly and the risks hierarchy determines which issue has the highest risk.

Figure 3. Pairwise Comparison Matrices for All Issues

Benefits

Employment	Welfare	Term	Budget	Scale
Welfare	1	7	6	.760
Term	1/7	1	2	.144
Budget	1/6	1/2	1	.096

Investment	Welfare	Term	Budget	Scale
Welfare	1	7	3	.682
Term	1/7	1	1/2	.103
Budget	1/3	2	1	.216

Infrastructure	Welfare	Term	Budget	Scale
Welfare	1	6	7	.758
Term	1/6	1	2	.151
Budget	1/7	1/2	1	.091

Fairness	Welfare	Term	Budget	Scale
Welfare	1	4	3	.625
Term	1/4	1	1/2	.136
Budget	1/3	2	1	.238

Costs

Education	Welfare	Term	Budget	Scale
Welfare	1	2	1/3	.222
Term	1/2	1	1/6	.111
Budget	3	6	1	.667

Safety	Welfare	Term	Budget	Scale
Welfare	1	2	1/2	.286
Term	1/2	1	1/4	.143
Budget	2	4	1	.571

Environment	Welfare	Term	Budget	Scale
Welfare	1	3	1/4	.226
Term	1/3	1	1/5	.101
Budget	4	5	1	.674

Defense	Welfare	Term	Budget	Scale
Welfare	1	2	1/2	.276
Term	1/2	1	1/5	.128
Budget	2	5	1	.595

Risks

Competition	Welfare	Term	Budget	Scale
Welfare	1	5	1	.444
Term	1/5	1	1/6	.084
Budget	1	6	1	.472

Human Rights	Welfare	Term	Budget	Scale
Welfare	1	5	2	.582
Term	1/5	1	1/3	.109
Budget	1/2	3	1	.309

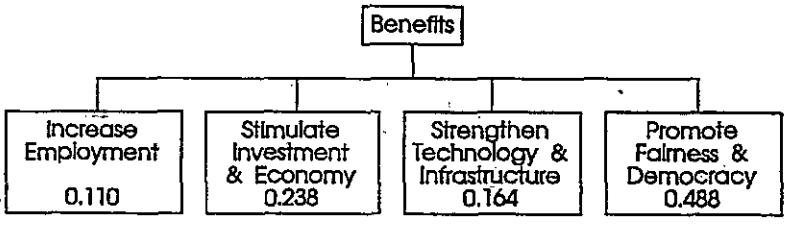
Burden	Welfare	Term	Budget	Scale
Welfare	1	9	1/2	.367
Term	1/9	1	1/9	.051
Budget	2	9	1	.582

Determining the importance of each alternative

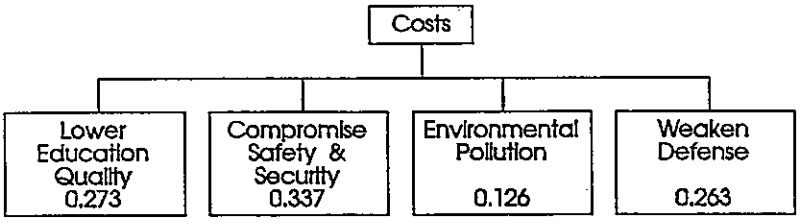
Having developed the priorities of the issues in the respective hierarchies, we return to the third level of each hierarchy in Figure 1. Each issue is now replaced by three pairs of alternatives, one pair for the actions of welfare issue, another for the actions of legislator's term issue, and the third for the budget issue. Each pair represents the status quo and the potentially new state obtained by changing from the status quo (See Figure 4). For instance, one compares the dominance of the decision 'to reform welfare' over the decision 'not to reform welfare', with respect to each criterion. Through pairwise comparison, a welfare reform rating, .847 (=.889×.110+.75×.238+.8×.164+.9×.488) and a 0.153 (=.111×.110+.25×.238+.2×.164+.1×.488) rating for no welfare reform are obtained. Both numbers can be found in Figure 4, second column from the right of the benefits hierarchy. We call them local ratings since this column only considers one issue at a time.

Local priority is converted to global priority by weighting through the corresponding issue's priority under each criterion. For example, with respect to Increase Employment in the benefits hierarchy, the priorities of (welfare, legislator's term, budget) issues are (.760, .144, .096) (see Figure 1). Suppose one uses pairwise comparison and finds the priorities of each of the three (change, no change) pairs with respect to this criterion from the corresponding column are (.889, .111), (.100, .900), (.333, .667). (see Figure 4). Each pair is then weighted by its corresponding importance, .760, .144, .096, respectively. Then by proportionality, the global rating for welfare reform under 'Increase Employment' criterion is .889 × .764 = .676. Similarly, for change on the other two issues with respect to this criterion are: .100 × .144 = .014 and .333 × .096 = .032. The procedure is repeated for 'no change' alternatives. In the end we have the six priorities (.676, .084), (.014, .130), (.032, .064). The global priorities are shown in the second columns under each criterion in Figure 4. The overall ratings for the six alternatives are shown at the rightmost column. For example, the overall rating for welfare reform under benefits

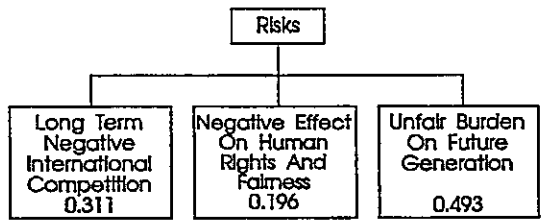
Figure 4. Global Rating for Each Alternative



	Increase Employment 0.110		Stimulate Investment & Economy 0.238		Strengthen Technology & Infrastructure 0.164		Promote Fairness & Democracy 0.488		Local Rating	Overall Rating
	Local	Global	Local	Global	Local	Global	Local	Global		
Welfare Reform	.889	.676	.750	.512	.800	.606	.900	.563	.847	.570
No Welfare Reform	.111	.084	.250	.171	.200	.152	.100	.063	.153	.105
Term Limit	.100	.014	.333	.034	.250	.038	.875	.119	.575	.074
No Term Limit	.900	.130	.667	.069	.750	.113	.125	.017	.425	.057
Balanced Budget	.333	.032	.400	.086	.500	.046	.900	.214	.653	.136
No Balanced Budget	.667	.064	.600	.130	.500	.046	.100	.024	.347	.057



	Lower Education Quality 0.273		Compromise Safety & Security 0.337		Environmental Pollution 0.126		Weaken Defense 0.263		Local Rating	Overall Rating
	Local	Global	Local	Global	Local	Global	Local	Global		
Welfare Reform	.400	.089	.466	.133	.333	.075	.200	.055	.362	.093
No Welfare Reform	.600	.133	.534	.153	.667	.150	.800	.221	.638	.165
Term Limit	.500	.056	.333	.048	.750	.061	.889	.114	.558	.071
No Term Limit	.500	.056	.667	.095	.250	.040	.111	.014	.442	.054
Balanced Budget	.900	.600	.834	.476	.883	.595	.900	.535	.875	.540
No Balanced Budget	.100	.067	.166	.095	.117	.079	.100	.060	.125	.076



	Long Term Negative International Competition 0.311		Negative Effect On Human Rights And Fairness 0.196		Unfair Burden On Future Generation 0.493		Local Rating	Overall Rating
	Local	Global	Local	Global	Local	Global		
Welfare Reform	.143	.063	.111	.065	.100	.037	.116	.051
No Welfare Reform	.857	.381	.889	.517	.900	.330	.884	.383
Term Limit	.600	.050	.400	.044	.500	.026	.512	.037
No Term Limit	.400	.034	.600	.065	.500	.026	.489	.036
Balanced Budget	.111	.052	.200	.062	.100	.058	.123	.057
No Balanced Budget	.889	.420	.800	.247	.900	.524	.877	.437

hierarchy is .570 (=.676 × .11 + .512 × .238+ .606 ×.164+ .563 ×.488). The overall ratings are then used to develop the final outcome of Table 2. This approach subsumes the yes-no voting approach and is much broader and better integrated.

Deriving the ratio

To combine the priorities derived from the three hierarchies, we divide the benefit results from the benefits hierarchy by those from the costs and risks hierarchies to obtain the final outcome (see Table 1). In this example we find that *welfare reform* benefits are the highest among all the alternatives, and its corresponding costs and risks are lower than those of the *no welfare reform*. Therefore, its ratio is much higher than that of the *No welfare.reform*. The former dominates the latter both when no risk is considered and also when projected risk is taken into account. Compared with the *no balanced-budget amendment*, the *balanced-budget amendment* benefits and costs are higher and its corresponding risks are lower. Its overall ratio is higher than that of the *no balanced-budget amendment* decision. *No budget reform* dominates *budget reform* when no risk is considered. When projected risk is taken into account, *budget reform* has the higher priority. Including risks by using possible scenarios of the future can be a powerful tool in assessing a decision. The same procedure is performed for legislator term issue. We find that *no term limit* dominates *term limit* by a very small margin.

Table 1. Actions to be Taken

Calculation of Benefits / (Costs × Risks) Ratio		To Do or Not To Do
Welfare Reform	$\frac{.570}{.093 \times .051} = 120.18$	Yes (By far over No)
No Welfare Reform	$\frac{.105}{.165 \times .383} = 1.66$	
Budget Reform	$\frac{.136}{.540 \times .059} = 4.42$	Yes (More than double No)
No Budget Reform	$\frac{.059}{.076 \times .437} = 1.72$	
Term Limits	$\frac{.074}{.071 \times .037} = 28.17$	No (Close to Yes)
No Term Limits	$\frac{.057}{.054 \times .036} = 29.32$	

About the Linked Issues

If we encounter the situation that acting on the second issue from the status quo requires also acting on the first issue to change from its status quo, then we would compare the sum of acting on the two issues. The sum of the ratios (benefits/costs×risks) for changing the two may exceed the sum of not doing both, even though taken singly, one of them may be rejected. For example, if "Term Limits" is required for "Budget Reform", then we should add the ratio of both (=32.59) and compare it with the sum of "No Term Limits" and "No Budget Reform" (=31.04). Since the former is larger, we would carry out both "Term Limits" and "Budget Reform". The object of this process is to integrate the issues so that decision makers would not arbitrarily decide on each issue alone as they do in ordinary voting. But by linking its ratio to the ratios of the other issues, they would weight it carefully by assigning it the appropriate strength (judgment). Otherwise, exaggerating its value would in the proportionality and normalization scheme unduly rob some other issue from its desired priority. We believe that this is a powerful way to pursue in order to determine the relative importance of the issues rather than to simply give one of them too high a value and give the other correspondingly a very low one or just to vote yes-no on them.

Sensitivity Analysis

To ensure that the outcome not be construed as a result of whimsical judgments, we performed a comprehensive sensitivity analysis. Sensitivity analysis helps decision makers discover how changes in the priority intensity affect the recommended decision. Judgments about the importance of each criterion are varied. There is a wide range of admissible priority values that a policy maker may choose for each criterion. The sensitivity analysis covers the reasonable priorities a politician might choose for each criterion. The importance of each criterion is changed by 30%. Thus it is altered to 0.40 of the original priority and to 1.40 of the original priority. In the mean time, the minimum priority value is limited to 0 and the maximum is to 1. Since each criterion is allowed to vary

twice, this yields 2×4=8 variations in the benefits hierarchy, 2×4=8 variations in the costs hierarchy, and 2×3=6 variations in the risks hierarchy. To cover all possible interactions, we generate 8×8×6=384 data points. From the analysis, we found that *welfare reform* always dominates *no welfare reform*, and when the burden on future generations is considered much less important, the *no balanced-budget amendment* dominates. The *no term limits* is preferred over *term limits* about 56% of the cases. The results suggest that welfare reform is the most pressing issue, while budget reform is important only if the effect on future generations is taken very seriously. The implications of *term limits* are still not clear in the debate.

5. Conclusions

We have identified some of the shortcomings of the traditional majority rule of voting, with which public policy makers have no way of expressing the intensity of their preferences. We develop and illustrate a voting procedure that is objective and takes into consideration each individual's sentiment and allows reasoning based on hierarchical analysis. The approach is general and easy to understand. It could have wider applicability in many real world problems and particularly in business and politics where one needs to know the best outcomes of debate and wheeling and dealing. With our proposed "cardinal" approach, decision making requires that one does one's homework carefully, providing judgments and deriving priorities. No matter how traditional and sacred it may be, raising one's hand to vote may be widely questioned as the best way to determine the outcome of several issues that are linked. We hope that this paper will help draw further attention to the subject.

We do not suppose that AHP is the best analytical tool to use. We also have no illusion that the world will hasten to implement our proposal. Rather, we believe the proposed method provides a way to make public decisions that has more precision, and we believe also validity, than what people have always done. It is sensible since it explores the strength of preference across issues. A shortcoming of this study is that it does not fully explore other alternative methods, and discuss relative advantages and disadvantages. We will continue the comparison in the future and would like our idea to be discussed by our thoughtful colleagues.