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Voting Power in the Governance of the International Monetary Fund

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Abstract. In general in an organisation whose system of governance involves weighted voting, a member's weight in terms of the number of votes and the formal power it represents differ. Power indices provide a means of analysing this difference. The paper uses new algorithms for computing power indices for large games. Three analyses are carried out: (1) the distribution of Banzhaf voting power among members in 1999; the results show that the United States has considerably more power over ordinary decisions than its weight of 17% but that the use of special supermajorities limits its power; (2) the effect of varying the majority requirement on the power of the IMF to act and the powers of members to prevent and initiate action (Coleman indices); the results show the effect of supermajorities severely limits the power to act and therefore renders the voting system ineffective in democratic terms, also the sovereignty of the United States within the IMF is effectively limited to just the power of veto; (3) the paper proposes the determination of the weights instrumentally by means of an iterative algorithm to give the required power distribution; this would be a useful procedure for determining appropriate changes in weights consequent on changes to individual countries' quotas; this is applied to the 1999 data. Policy recommendations are, first, that the IMF use only simple majority voting, and discontinue using special supermajorities, and, second, allocate voting weight instrumentally using power indices.

Keywords: power indices, Banzhaf index, Coleman index, IMF, Keynes

This paper examines how the rules of the IMF and their implementation affect the voting power of its member countries and its capacity to make decisions, and makes recommendations for changes.

Fundamental decision making at the IMF uses a system of weighted voting in which member countries and executive directors cast different numbers of votes reflecting their respective financial contributions. It is well known that a property of such weighted voting systems (other examples are the EU Council of Ministers, shareholders' meetings in joint stock companies) is that a member's power – in the sense of its general ability to influence decisions – is not the same as its share of the votes. The system is designed to give power unequally to different members but its implementation might result in too much or too little inequality.

The most important decisions require special majorities of 85% of the votes, giving the USA – with over 17 percent – an effective veto. This very high majority requirement has been criticised as both likely to make the decision making system too rigid and also

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to be damaging to American sovereignty by making it easier for others to block US proposals. When the Bretton Woods system was being planned in 1943, John Maynard Keynes warned of this.

This paper uses game-theoretic measures of voting power to answer the following questions:

1. Is the inequality of voting power between countries a fair reflection of the differences in their respective contributions?
2. How does the size of the majority requirement employed affect the voting powers of the main contributors and the effectiveness of the IMF in being able to make decisions by majority voting?
3. How *should* the votes be weighted to give each country a given share of the power to influence decisions in general?

The findings, using the voting weights for 1999, are that:

1. Countries' voting powers over ordinary decisions are much more unequal than their financial contributions; the power of the USA is much greater than its nominal 17% of the votes.
2. The effect of the special 85% majority requirement for major decisions is to severely limit the effectiveness of the decision-making system.
3. The use of the 85% majority requirement is counterproductive to the US pursuing an active role in the IMF by limiting its power to have its policies accepted.
4. The IMF should make all decisions by simple majority and scrap special majorities. That would make its democratic decision making system most effective.
5. The United States should support the use of simple majorities for all decisions if it wishes to increase its influence within a democratic IMF.
6. Votes of all members and executive directors should be reweighted in order to give the desired share of voting power to each country and director.

0. Introduction

The system of governance of the IMF is of considerable interest as a research topic not only because of the crucial importance of international financial organisations to the management of the world economy in an era of increasing globalisation. Current discussions surrounding the reform of the architecture of the international economic institutions give it unprecedented topical relevance. The IMF is also a worthwhile subject of research from the general point of view of the design of voting systems because it is one of a number of international organisations that operate on the basis of the weighted voting power of their members (the World Bank, the European Union Council of Ministers and regional development banks are some of the others; in contrast, for example to the United Nations General Assembly or the World Trade Organisation which use one-member-one-vote). Weighted voting is used because inequality of voting power between countries is a fundamental design feature intended to reflect inequality of contributions of resources. However, weighted voting raises the important question of whether the resulting inequality of power over actual decisions is precisely what was intended for the relationship between power and contribution.

On any reasonable definition of voting power as a measure of its ability to influence voting outcomes, there is not an exact correspondence between a member's power and its nominal voting strength. It has long been known (e.g., Shapley and Shubik [29], Banzhaf [1], Coleman [3]) that in general, in a body which makes decisions by weighted voting, there is no simple relationship between formal voting power and voting weight.[1] In many weighted voting bodies which have been studied power has been found to be much more unequally distributed than nominal votes so that looking only at the latter can give a false picture. Members with very large voting weight can possess a disproportionately greater voting power – they have in a sense an extra "invisible weighting" – and other members proportionately less. Similarly it is possible for individual voters to have no power at all despite possessing an apparently significant number of votes.[2]

It is therefore of intrinsic interest to consider the IMF voting system from this point of view, by analysing the distribution of a priori voting power.[3] There are only two studies which have adopted a similar approach to the analysis of power in the IMF to the one employed here: those by Dreyer and Schotter [4] and Strand et al. [31]. Analysing the current voting system using the game-theoretic technique of voting power indices to find the distribution of power between member countries which results from weighted voting is the first aim of this paper.

At the original Bretton Woods conference during the Second World War, at which the plans for what became the IMF and World Bank were originally agreed, the design of the voting system was an important area of debate in which significant differences emerged between the British and American delegations. The United States was always concerned to retain a national veto for itself over the most important decisions while the British preference was for simple majority voting in all matters. The American proposal was that major decisions would require a special majority of four-fifths of the votes to pass thereby ensuring that the USA, then with 33 percent of the votes, would be able to block any proposals it did not like. The leader of the British delegation, John Maynard Keynes, criticised this plan and pointed out that, rather than enhancing America's sovereignty, it might actually reduce it because the use of special majorities could also lead

[1] In accounts of the IMF voting system the term "voting power" is commonly used to denote the number of votes (or fraction of the total) commanded by a member country. Since in this paper I am making a fundamental distinction between this and actual power as defined, I use the term voting weight instead.

[2] A well-known example of this was Luxembourg in the EEC Council of Ministers before 1973, whose one vote was never able to make any difference given the votes of the other countries.

[3] This is fundamentally different from attempting to draw conclusions from analyses of *observed* voting behaviour. I am concerned here with the formal properties of the voting system and the rules governing the IMF.

to a group of smaller countries being able to block its own proposals. Nevertheless the American view prevailed and special majorities have been a fundamental feature of the IMF constitution ever since. I examine this issue of the choice of majority requirement in detail as the second aim of the paper. The results provide powerful evidence in support of the insights of Keynes.[4] The method used is that of Coleman [3] which emphasises the distinction between the power of a member to initiate action and its power to prevent action when there is a supermajority requirement, particularly appropriate in this case. It also gives a measure of the body's own power to act. This latter is useful as an indicator of the effectiveness of the voting system as a means of decision making.

The third question addressed is how the voting weights *ought* to be allocated in order to give rise to a given predetermined power distribution. It is a basic principle of the IMF that a member's voting power should reflect its financial contribution and therefore it is natural to choose the voting weights in such a way that the resulting voting powers of members follow this rule. I propose an iterative algorithm in which voting weights are treated instrumentally and are chosen so that the associated power distribution, as measured by power indices, is predetermined.

This paper addresses the following specific questions:

(1) How does the voting power of individual countries compare with their nominal votes? To what extent is the degree of inequality in the distribution of votes reflected in the distribution of voting power?

(2) Are there important differences in the distribution of voting power between the two main IMF decision-making bodies, the Board of Governors and the Executive Board?

(3) Different types of decisions use different decision rules, some requiring a special supermajority. What effect do different decision rules have on the distribution of power and also on the power of the voting body itself to act?

(4) Can we determine what the voting weights should be as the source of a given distribution of power? I investigate this question taking the different member countries' IMF quotas as the preferred distribution of power.

The analysis is entirely in terms of *formal* voting power and the formal constitution as laid down in the Articles of Agreement and its amendments; the allocation of voting weight among the members is taken at face value. It is commonplace however to note that the organisation is in practice dominated by the United States and the advanced industrial nations since their combined voting weight gives them a majority over the

[4] In effect the requirement of a high special majority has other effects than simply giving an American veto: it makes the distribution of voting power more equal and therefore limits American power within the organisation. It also reduces the number of votes that result in a decision and therefore limits the effectiveness of the voting system as a democratic process.

developing countries. The analysis presented here is not primarily concerned with such questions about the power of informal groupings of countries.[5]

Despite the importance that member countries attach to the voting system, and to their relative voting strengths within it,[6] in practice actual votes are very rarely called in meetings of the IMF.[7] Indeed they are deliberately avoided, especially in the Executive Board, in order "to avoid the element of confrontation associated with a contested vote"; decisions are taken only after discussion leading to a consensus whenever possible. It might therefore be suggested that an analysis of voting power is beside the point if all decisions are taken by consensus. However, formal voting procedures have a fundamental influence over the *de facto* decision making process; power relationships are fundamentally determined by relative voting strengths and the fact that member countries or directors are not called on to cast their votes in meetings is a reflection that these are well understood. The distribution of voting power provides a framework within which bargaining takes place between countries before a decision is taken.

1. Formal decision making in the IMF

There are two decision-making bodies: the Board of Governors and the Executive Board.[8] All powers of the IMF are vested in the Board of Governors, which delegates to the Executive Board authority to exercise all except certain specified reserved powers; the Executive Board is responsible for the general operations of the IMF.[9] The powers exercised by the Board of Governors and expressly reserved to it by the Articles of Agreement refer to matters of a fundamental or political nature or which may have a

[5] Although the methodology can obviously and usefully be employed to evaluate and compare the voting power of groupings which did not have an actual majority. For example it would be possible to use this approach to comment on the criticisms made by developing countries that the distribution of voting power has been too heavily weighted towards developed countries. This is a consequence of a fundamental aspect of the design of the IMF that dominant voting power should be in the hands of creditor nations who provide the resources. Our analysis should be able to illuminate the extent to which this aim is fulfilled in practice or whether the "invisible weighting" of the United States and other large creditors skews the power distribution even further away from the debtor countries.

[6] See Zamora [32]; also Sadako [28] for an account of the campaign mounted by Japan to increase its voting weight.

[7] There is an analogy between voting and power distributions among the countries which are members of the IMF and those among shareholders of a commercial joint stock company (the Board of Governors corresponding to the shareholders' meeting). Although it is relatively rare for them to cast their votes in ballots taken at company AGMs, nevertheless large investors are influential with top management because their voting weight is powerful in a formal sense. There is an important structural difference with joint stock companies however in that weighted voting is a central feature of the day-to-day operations of the IMF, in the Executive Directors as well as the Board of Governors, whereas the directors of a commercial company do not use weighted voting.

[8] See Gold [10] for a full account of the constitution of the IMF.

[9] The effective governing body is the International Monetary and Financial Committee (previously known as the Interim Committee) consisting of ministers of countries with seats on the Executive Board. This study, however, is concerned only with the formal rules of decision making.

profound economic impact; these include the power to admit new members, require a member to withdraw, approve a revision of quota and determine the number of Executive Directors who are elected. Some powers are vested in the Executive Board and the exercise of them does not depend on delegation from the Board of Governors, such as the election of the Managing Director and the power to suspend or terminate suspension of certain provisions. As well as exercising the powers either vested in them or delegated to them, an important role of the Executive Board is to make recommendations to the Board of Governors about decisions which the latter is to take. The Board of Governors delegates much actual policymaking to the Executive Board and its own meetings are often therefore largely ceremonial.

The Board of Governors, which in 1999 had 178 members, comprises one governor appointed by each member country – usually the minister of finance or the governor of its central bank – and meets biannually. Decisions, in the form of resolutions, are taken by a simple majority of the votes cast except on certain matters requiring an 85% special majority. The executive directors, who are officials rather than politicians, are either appointed or elected. Like the Board of Governors, the Executive Board employs weighted voting and therefore it is appropriate to consider its composition and analyse the distribution of voting power among the executive directors separately from the Board of Governors. There are currently twenty four executive directors, five appointed by the five member countries having the largest quotas, and nineteen elected by the other members. Elections of executive directors are held every two years. There is a minimum and a maximum percentage of the eligible votes that a nominee must receive in order to be elected. In practice the minimum percentage requirement means directors normally need the votes of more than one country in order to be elected. There are currently three single-country constituencies, however: China, Russia and Saudi Arabia. The principle behind the requirement of a minimum percentage vote is to encourage the formation of coalitions of members with common interests who elect directors to represent them, while the requirement of a maximum percentage prevents too great disparities in the voting strength of individual elected directors.

An executive director casts the votes of all those members who voted for him as a unit and cannot split the vote. With the exception of the three groups of Latin American republics, the Articles do not associate executive directors with defined regional or other constituencies; the constituencies are assumed to emerge informally as part of the election process. Members which combine to form groupings to elect a director engage in negotiations among themselves through channels which are outside the formal rules of the IMF. However the operation of the system over the years has led to the creation of several more or less permanent constituencies most of which have a geographical basis. Some have tended to elect an executive director from the same country over several elections and have a relatively stable membership. Some member countries – Australia, Brazil, Belgium, Canada, China, India, Italy, Netherlands – have provided elected executive directors virtually continuously since 1946.

Given the existence of the constituencies around the election of executive directors, it might be considered appropriate in a study such as this one, to model the power relationships in the Executive Board in terms of a two-stage process: first, members use their weighted votes within their group to elect a director; second, their elected director casts their combined votes as a bloc in the Executive Board. This two-stage approach would assign a greatly increased voting power to certain members. In 1999, Italy, Canada, Brazil, India, Argentina and Switzerland all had more than half the votes of the constituency that elected their directors, and Netherlands, Belgium, Australia and Indonesia were all effectively dominant, though short of an actual majority. For example the director from Italy, a country with 3.3 percent of the votes, casts 4.27 percent of the votes in the Executive Board on behalf of a grouping of Mediterranean countries. This two-stage approach, however, has not been pursued here since it would require the existence of the constituencies to be fixed independently of the outcome of the first stage, which cannot be assumed under the rules. It would also require a similar process for the election of directors be followed within each constituency, which cannot be assumed either; or failing that, at least the researcher would need knowledge of how decisions are taken.[10] It is an interesting topic that is not considered here and remains for future work.

2. The use of special majorities and the views of Keynes

Except as specifically provided for in the Articles, all decisions of both the Board of Governors and the Executive Board – that is, most of the decisions of the IMF – are made by a simple majority of the votes cast.[11] Certain categories of decision, however, require special 85 percent majorities. These tend to be the most important types of decision where a degree of consensus is needed to make them effective. This supermajority requirement has been set at a level which gives the United States a veto.[12] However it also means that groups of other countries, if they formed a bloc, such as the EU or the developing countries could also have a veto on proposals by the United States. The use of a special supermajority requirement is actually a move towards a unanimity rule and in fact results in substantially greater equality of power, as shown later.

The question of the size of majority required for a decision was a point of disagreement between the British and American founders of the IMF. Keynes was little interested in decision rules based on precise formulae and advocated, in effect, that all decisions be taken by simple majority, in contrast to the Americans who insisted on voting rules which gave them a veto. Keynes addressed the question in his maiden speech to the House of Lords (Keynes [15]): "... the requirement in the American plan for a four fifths majority will be found, if the paper is read carefully, to relate not to all matters by any means, but only to a few major issues. Whether on second thoughts any one would wish to allow a negative veto to any small group remains to be seen. For example, the American

[10] For example the Scandinavian group chooses its director by rotation rather than by voting.

[11] The rule is in terms of votes cast rather than total votes but this distinction is ignored in this study because of its emphasis on a priori voting power rather than behaviour.

[12] It was increased from 80 percent in 1969 to allow the USA to keep its veto while reducing its financial contribution.

proposals might allow the gold-producing countries to prevent the United States from increasing the gold value of the dollar, even in circumstances where the deluge of gold was obviously becoming excessive; and in some ways, by reason of their greater rigidity, the American proposals would involve a somewhat greater surrender of national sovereignty than do our own." He also wrote (Keynes [16]): "I disagree strongly, on non-economic grounds, of the individual country veto-power unless it is granted to all countries regardless of their quotas … the 80 percent majority rule would limit the power of the US with respect to changes it may desire in an existing status as much as it would increase its power to stop undesired changes." The results of an analysis of the effect of varying the special majority requirement, presented below, supports this argument.

3. Voting weights

Every member of the IMF has a quota expressed in US dollars which is its subscription to the resources of the organisation and also determines its voting weight. The votes allotted to a member are equal to a basic two hundred and fifty plus one vote for each hundred thousand dollars of quota. Thus voting weight varies linearly according to the size of the quota rather than proportionately. This is one important difference with a business corporation where votes are strictly proportional to contributions to equity capital. The existence of the 250 "basic" votes which every member has independently of its quota reflect concerns expressed at the Bretton Woods conference. It was felt that what was then a radical move (in an international organisation) of adopting a system of weighted voting for the Bretton Woods institutions, where the weights reflected economic and financial factors, should be tempered by the political consideration of the traditional equality of states in international law. To have allocated votes in proportion to quotas would have meant too close a similarity with a business corporation and might have given too high a degree of control to a small group of member countries.[13]

Basic votes are not increased when quotas increase and for most countries their voting weight has become almost proportional to their quota as the latter has increased over the years. The proportion of total votes represented by the combined basic votes has accordingly fallen substantially over the years from a high of over 14% in 1956 to 2.1% in 1999. This decline has been in spite of the increase in the number of members, many of which are developing countries with very small quotas. However for the great majority of members their basic votes have become insignificant. For example for Belgium the share of its total voting weight represented by basic votes has fallen from 10% in 1946 to 0.77% in 1999, for Mexico it has fallen from 21.7% to 0.96% over the same period.

4. The measurement of a priori voting power

The relationship between a member's weight and power can be examined by the method of power indices based on formally treating the voting body as an n-person co-operative

[13] See Gold [11,12].

game, specifically here a weighted voting game. Given its general or a priori nature, which abstracts from the particular identities, characteristics or interests of named individuals, this approach is useful in the design of constitutions that embody differences in voting power between members. There are a number of good accounts of power indices but the best recent treatment is Felsenthal and Machover [6].[14] A power index is based on the idea of power in a weighted voting game as influence over decision making in general, that is without regard for the issue to be determined and therefore the players' preferences.

The power of a member of a voting body (in this case a member country of the IMF) is defined as its ability to join coalitions of other members formed by voting and change them from losing to winning, or, equivalently, to change them from winning to losing by defecting. The essential utility of this approach is that it focuses on the theoretically possible *outcomes* of the voting system, and bases its account of power on them, rather than simply looking at the *inputs* to the voting system, in terms of the numbers of votes possessed by each member, and naïvely assuming that these are reflected in power. It extends our understanding by revealing properties of the voting system.[15]

A voting body can be thought of as a *weighted majority game* defined by the set of its members, $N = \{1, 2, \dots, n\}$, their voting weights, $w_1, w_2, \dots, w_n$ and a decision rule in terms of a quota q.[16] In the present case the weights are proportions so that $\sum w_i = 1$. A swing for player i is a coalition represented by a subset S, $N \supseteq S$, $i \notin S$, and a *quota* q such that

$$\sum_{j \in S} w_j \leqslant q \quad \text{and} \quad \sum_{j \in S} w_j + w_i > q.$$

S is a *losing coalition* while $S + \{i\}$ is a *winning coalition*. Let the number of swings for player i be η_i; this can be written formally $\eta_i = \sum_S 1$, the summation being taken over all swings. The total number of swings for all players in the game is $\overline{\eta} = \sum \eta_i$. Each subset of N, that does not include i represents the outcome of a vote of all the other $n-1$ players. The total number of such possible votes and therefore the maximum possible number of swings for player i is 2^{n-1}.

In the terminology of game theory,[17] the games considered here are *proper*, i.e., games in which the complement of any winning coalition is necessarily losing, thus

[14] See also Brams [2], Dubey and Shapley [5], Lucas [23], Roth [27], Straffin [30] and Owen [25].

[15] Power indices have been the subject of repeated trenchant criticisms by Garrett and Tsebelis [8] and [9] who attacked a study of the EU Council of Ministers by Hosli [13]. They made the extreme claim that "[the method of power indices] generated *no* analytic leverage over decision making in the contemporary EU". They argued that, because it is concerned with a priori voting power only and ignores preferences, it cannot have anything to say about behaviour. However, their target is really a straw man because power indices do not claim to model *behaviour*, but to be a tool for the design of institutions. See Lane and Berg [17] for a reply. This point was made very clearly in the seminal contribution by Shapley and Shubik [29].

[16] This is here used as a technical term for the majority requirement and should not be confused with IMF quotas.

[17] Dubey and Shapley [5].

ruling out the possibility of having two contradictory decisions: if $S + \{i\}$ is winning, then $N - S - \{i\}$ is losing. For a general weighted voting game this requires $q \geqslant \sum w_i/2$, and in this case $q \geqslant 0.5$. In the analysis of the IMF below, two quotas are taken, $q = 0.5$ or $q = 0.85$, both of which satisfy this condition.

A proper game does not necessarily lead to a decision, however, because some coalitions, while not being winning, may be able to prevent a decision. Such a *blocking coalition* is a losing coalition whose complement is losing: S is a blocking coalition if both S and $N - S$ are losing. A *strong game* is one without blocking coalitions: the complement of a losing coalition is necessarily winning. A *decisive game* is then defined as one that is both proper and strong: in this case the complement of a winning coalition is necessarily losing (no nonintersecting pair of coalitions being simultaneously winning) and that of a losing coalition is necessarily winning (no nonintersecting pair of coalitions being both blocking).[18]

A power index is an n-vector containing a value for each player. Two Banzhaf measures of power are defined:

The *non-normalised Banzhaf index* for player i is the proportion of votes which are swings for player i:

$$\beta_i' = \frac{\eta_i}{2^{n-1}}, \quad i = 1, 2, \ldots, n.$$

This measures the absolute power of each player as a probability. It indicates relative voting powers of different players but does not have a direct interpretation as giving a power distribution. For that we use the normalised version, the Banzhaf index.

The *Banzhaf index* for player i:

$$\beta_i = \frac{\eta_i}{\overline{\eta}} = \frac{\beta_i'}{\sum \beta_i'}, \quad i = 1, 2, \ldots, n.$$

The Banzhaf index is the ratio of the number of swings for member i to the total number of swings for all members. It is interpreted as the share of player i in the power of all players to influence decisions by means of a swing. The index is normalised to sum to 1 over all members. This way of thinking about and measuring power has been a fundamental part of the literature ever since the seminal articles of Shapley and Shubik and of Banzhaf.[19] It has its intellectual origin in the parallel between the idea of sharing of power in a legislature and bargaining among players in a co-operative game, that goes back to the Shapley value (of which the Shapley–Shubik index was a specialisation).

[18] Neither of the IMF voting games considered in this paper is decisive. Voting on special decisions requiring $q = 0.85$ is not a decisive game because it is a non-strong game. This point is important when considering Coleman's indices in the next section. Voting on ordinary decisions with $q = 0.5$ may not technically be decisive depending on the weights of the members: it is possible under the rules for there to be two nonintersecting coalitions each with a weight of precisely 0.5.

[19] But not the ancestral article on measuring voting power by Penrose [26]. The non-normalised Banzhaf index was actually invented by Penrose. Felsenthal and Machover [6] attributed this correctly but I have kept to the more familiar term here.

The literature on power indices casts little light on the relative usefulness of the Banzhaf index and the Shapley–Shubik index as rival measures of power and this indeterminacy has hindered the wider application of the approach. They have often given different results where they have been compared in the same application and the literature has been able to offer little guidance on how to resolve these problems. It is not uncommon for empirical studies to present analyses using both indices without comment. In this study however I justify my preference for the Banzhaf index on the basis of the critique in Coleman [3] and by Leech [20]. The latter, a direct empirical comparison in an application to voting in joint stock companies, found the results using the Shapley–Shubik index to be inconsistent with independent evidence while the Banzhaf index was not.[20]

The normalised Banzhaf index provides a measure of the relative power of each member for a given quota q; it does not permit comparisons between games with different quotas since the denominator, $\overline{\eta}$, changes with q. An analysis of the effect of changing the quota q requires consideration of absolute rather than relative voting power for which a normalised index is not suitable. The non-normalised Banzhaf index can be used for such an analysis. However, when the decision rule requires a supermajority, with the quota $q > 0.5$, the game ceases to be decisive and blocking power becomes important. It becomes of interest to make a distinction, in terms of measures of absolute voting power, between a member's power to block or prevent a decision, on the one hand, and its power to win or initiate a decision, on the other. This is especially true of the IMF where the veto power of the United States is so important to decisions requiring $q = 0.85$. I suggest that the indices proposed by Coleman are useful for this and these are discussed in the next section.

5. The Power to Act, and the Powers of Members to Initiate and Prevent Action: The method of Coleman

A subtly different perspective on power measurement (and a fundamental critique of the Shapley–Shubik index) was provided in the classic paper by Coleman [3]. This paper is widely cited but its main points are not taken sufficiently seriously, with many accounts treating it as essentially just another presentation of the Banzhaf index.[21] Many authors refer to the Banzhaf index as the Banzhaf–Coleman index.

[20] Felsenthal and Machover [6] look into this question very closely and are also somewhat critical of the Shapley–Shubik index. They make a distinction between I-power and P-power, the former being voting power on issues which are concerned with public goods, power as influence, while the latter is about issues which involve a division of the spoils, as in parties forming electoral coalitions and then dividing up the offices among themselves after winning, as in a presidential system. They argue that the Shapley–Shubik index is inappropriate as a measure of I-power and prefer one of the versions of the Banzhaf index. Shapley–Shubik indices for the IMF in 1996 are provided in Leech [19] and, in 1999, in Leech [22].

[21] He did not actually mention the Banzhaf index although his coalitional model was the same.

In fact Coleman's paper is the foundation of a different approach to the analysis of power based on a rejection of the idea of sharing power among the members of a legislature. Coleman argues that the distributional consequences of a decision about public goods, taken by voting, are particular and cannot be conceived of in terms of a division of the spoils among members of the winning coalition. A vote usually leads to some action being taken which has a fixed profile of consequences for the members. Pure public goods are indivisible and non-excludable and therefore it is inappropriate to imagine them being divided up in different ways among the members of society.

Coleman argued that when designing the constitution of a voting body it is necessary to consider not only the power of each individual member, but also that of what he called the collectivity (in our terms, voting game) itself, which he called *the power to act*. An example that illustrates the importance of this distinction, especially when considering what the quota should be, is as follows. A requirement that all members be unanimous would make it very unlikely indeed that a decision were ever taken – and therefore the voting body would possess very little power to act. On the other hand, a very weak requirement – for example if a decision only required one member to vote for it to pass – would mean that the body would be very powerful in having a very great power to act. In both cases however members would have the same power relations: all would have the same value of the normalised Banzhaf power index, $\beta_i = 1/n$.

This is an important aspect of the design of voting systems; it is necessary to know not only the *relative* power of each member but also how much *absolute* power each possesses and also the ease of decision making in general, the power to act, which is a property of the voting body *as a whole*. In some cases it is important that a constitution make it difficult for a decision to be made, in order, for example, to protect minorities from arbitrary decisions taken by the majority, or to force legislators to reconsider their initial proposals before making a final decision under a system of checks and balances. In other cases there is a need for a responsive system that makes it easy to take a decision, such as where actions have to be taken under the urgent pressure of events.[22]

Coleman defined three indices as follows.

The Power of the Body to Act (PTA). This is defined for the body itself as the ease with which members' interests in a vote can be translated into actual decisions. It is measured as the proportion of all the theoretically possible voting outcomes that give rise to a decision. The index is defined as:

$$\mathrm{PTA} = \frac{\omega}{2^n},$$

where ω is the number of outcomes that have winning coalitions, and there are 2^n voting outcomes, equal to all the subsets of N. ω depends strongly on the quota q. For example a unanimity requirement ($q = 1$) would give $\omega = 1$ and a value of PTA equal to 2^{-n}, while a value of $q = 0.5$ would give $\omega = 2^{n-1}$ giving PTA $= 0.5$. The power to act satisfies the inequalities: $2^{-n} \leqslant \mathrm{PTA} \leqslant 0.5$, if $0.5 \leqslant q \leqslant 1$.

[22] The capacity of the institution to act has recently been studied in the context of the EU by Hosli [14], Felsenthal and Machover [7], Leech [21] and others.

The Power of a Member to Prevent Action (PPA_i). The power of a member to prevent action is a measure of its ability to block a decision by means of a swing. It is the proportion of outcomes with winning coalitions that are also swings for player i, and therefore represents the capacity of i to change a winning vote into a losing one. Thus, the power of member i to prevent action is defined as:

$$\mathrm{PPA}_i = \frac{\eta_i}{\omega}.$$

The Power of a Member to Initiate Action (PIA_i). The power of player i to initiate action is defined as the number of swings relative to the total number of voting outcomes that do not have a winning coalition. This index measures the potential of i to swing a coalition from losing to winning. Thus the power to initiate action is defined as:

$$\mathrm{PIA}_i = \frac{\eta_i}{2^n - \omega}.$$

In general for a proper game, the three absolute indices for player i satisfy:

$$0 \leqslant \mathrm{PIA}_i \leqslant \beta_i' \leqslant \mathrm{PPA}_i \leqslant 1.$$

The distinction between preventing action and initiating action only matters when the decision rule is based on a supermajority quota, $q > 0.5$, and therefore the game is not decisive. In the case of simple majority voting, when $q = 0.5$, the game is decisive and the two indices are identically equal to each other and to the non-normalised Banzhaf index. In this case, $\omega = 2^{n-1}$ and therefore:

$$\mathrm{PIA}_i = \frac{\eta_i}{2^n - 2^{n-1}} = \frac{\eta_i}{2^{n-1}} = \mathrm{PPA}_i = \beta_i'.$$

In the general case the relations between the non-normalised Banzhaf index and Coleman's indices can be written:

$$\beta_i' = \frac{\eta_i}{2^{n-1}} = \frac{2\eta_i}{\omega}\frac{\omega}{2^n} = 2\mathrm{PPA}_i\mathrm{PTA},$$

and

$$\beta_i' = \frac{\eta_i}{2^{n-1}} = \frac{2\eta_i}{2^n - \omega}\frac{2^n - \omega}{2^n} = 2\mathrm{PIA}_i(1 - \mathrm{PTA}).$$

The non-normalised Banzhaf index combines the individual player's power either to prevent action or to initiate action with the power of the body as a whole to act.[23] Moreover, as has been pointed out many times in the literature, both the Power to Prevent Action and the Power to Initiate Action are rescalings of the non-normalised Banzhaf index, and hence of the Banzhaf index. It is for this reason that the name Banzhaf–Coleman index is often used.

Coleman's indices, therefore, add nothing to the analysis in two special cases:

[23] It is also of interest to note that the power index β_i can be shown to be the harmonic mean of PIA_i and PPA_i: $1/\beta_i = (1/\mathrm{PPA}_i + 1/\mathrm{PIA}_i)/2$ (Dubey and Shapley [5]).

(1) where the voting body uses a simple majority rule with a quota $q = 0.5$; and,

(2) where the study of power is in terms of shares, and it is required that the power indices be normalised to sum to unity.

They are, however, a useful tool in other cases. In the study of the voting system used by the IMF they provide valuable insights into the effect of the choice of quota on the power to act and also into the trade-offs faced by the members, particularly the USA, between their national powers to prevent or initiate action and the power of the body to act.

6. The distribution of voting power in the IMF

Banzhaf power indices have been calculated for both voting bodies and for each majority requirement using the weights for 1999.[24] The results for the Executive Board and for the larger countries in the Board of Governors are shown in table 1. Direct comparisons are possible for the largest five member countries that appoint their own directors, whose weights in the Executive Board are the same as in the Board of Governors: USA, Japan, Germany, France and UK; they can also be made for the countries whose director is elected by a constituency of one: Saudi Arabia, Russia and China.[25]

These results show, first, that the majority requirement is very important and that the effect of the special 85% supermajority requirement is to equalise voting power to a very great extent. Second, the results for ordinary decisions using the 50% majority rule show that power is more unequally distributed than intended. The United States has more power than its voting weight in both bodies: more than 22 percent in the Executive Directors and 25 percent in the Board of Governors against 17 percent of the voting weight, all other directors or members have slightly less power than weight. Therefore for ordinary decisions the existing weighted voting system disproportionately favours the USA. Third, the results for the largest five countries in the two bodies are broadly similar for ordinary decisions.

7. The effect of the majority requirement on the power index

The results in table 1 show that the distribution of power depends strongly on the majority requirement q, being very different for ordinary decisions ($q = 50\%$) and decisions requiring special majorities ($q = 85\%$). It is therefore of interest from the point of view

[24] Voting weights taken from the IMF Annual Report for 1999. All the indices have been computed using the algorithm in Leech [22] for power indices in large games.

[25] The positions of the latter countries in the table are different in the two bodies because the weights in the Executive Board are those cast by directors and those in the Board of Governors those of members; both sides of the table present the results in order of the voting weight of the country. The algorithm used to find the power indices, from Leech [22], uses a partition of members into two groups, m large and $n - m$ small. In all the calculations in this study, I used $m = 8$.

Table 1
Votes and voting power indices 1999.

Executive Directors				Board of Governors			
	Weight	$q = 50\%$	$q = 85\%$		Weight	$q = 50\%$	$q = 85\%$
USA	17.53	22.27	6.45	USA	17.55	25.40	3.573
Japan	6.29	5.94	5.87	Japan	6.30	5.55	3.565
Germany	6.15	5.81	5.82	Germany	6.15	5.44	3.564
France	5.08	4.80	5.33	France	5.08	4.56	3.538
UK	5.08	4.80	5.33	UK	5.08	4.56	3.538
(Netherlands)	4.97	4.70	5.28	Italy	3.34	3.03	3.314
(Belgium)	4.49	4.24	4.98	Saudi Arabia	3.31	3.00	3.305
(Mexico)	4.36	4.12	4.89	Canada	3.02	2.74	3.209
(Italy)	4.27	4.03	4.83	Russia	2.82	2.56	2.871
(Canada)	3.78	3.57	4.42	Netherlands	2.45	2.23	2.799
(Denmark)	3.59	3.38	4.25	China	2.22	2.02	2.698
(Australia)	3.41	3.21	4.08	India	1.98	1.80	2.538
Saudi Arabia	3.31	3.12	3.99	Switzerland	1.64	1.50	2.252
(Thailand)	3.22	3.04	3.90	Australia	1.54	1.40	2.146
(Angola)	3.19	3.01	3.87	Belgium	1.48	1.34	2.078
Russia	2.82	2.66	3.49	Spain	1.45	1.32	2.050
(Egypt)	2.85	2.69	3.53	Brazil	1.45	1.32	2.044
(Switzerland)	2.67	2.52	3.34	Venezuela	1.27	1.15	1.837
(Brazil)	2.52	2.37	3.17	Mexico	1.23	1.12	1.795
(India)	2.46	2.32	3.10	Sweden	1.14	1.04	1.682
(Iran)	2.44	2.30	3.08	Argentina	1.01	0.92	1.510
China	2.22	2.09	2.83	Indonesia	0.99	0.91	1.486
(Chile)	2.01	1.89	2.58	Austria	0.90	0.82	1.352
(Gabon)	1.19	1.12	1.57	...	...	...	...
Sum	99.9	100	100	Sum	100	100	100
Exec Directors	24			Members	178		

Notes: Banzhaf Power indices. All figures are percentages. Votes do not sum exactly to 100 in the Executive Directors because members who did not cast their votes were not represented. Names in brackets are the countries of the Executive Director elected by a group; the number of votes is that of the group. Names not in brackets are countries with an elected director in a group of one.

of design of the voting system to investigate this effect further. We know that increasing q makes the power distribution more equal until in the limit when $q = 100\%$ power indices are equal for all members. This analysis may also provide some evidence on the question of the best majority requirement to use from the point of view of members' individual voting powers and the assertion of Keynes quoted above.

Figure 1, and its associated table, shows the effect of varying q on the power indices, in the Board of Governors, for the largest five countries. On the horizontal axis is the majority requirement q, varying from 0.5 to 1 in increments of 0.05, and the corresponding Banzhaf indices on the vertical axis. These results show that the country most affected by the majority requirement is the USA whose power index declines steeply as q rises. The USA has little more voting power than any other country for q greater

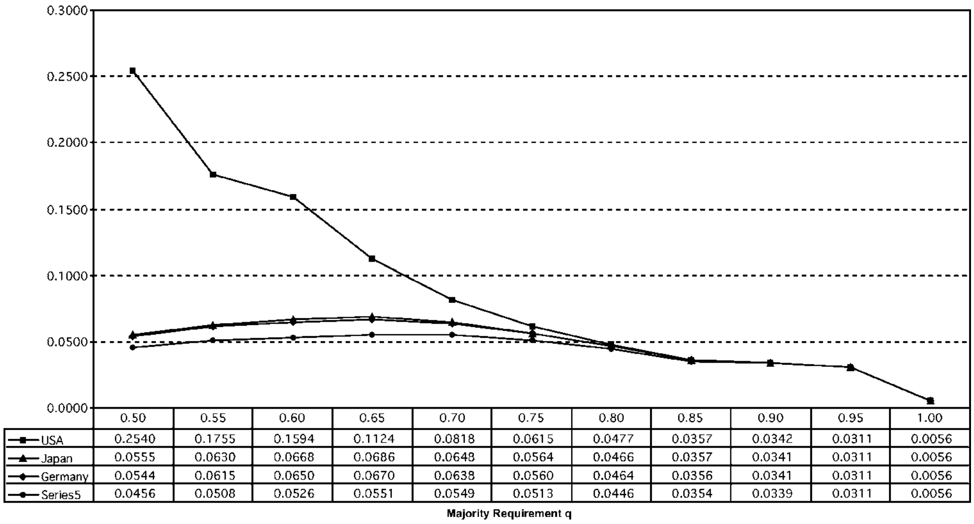

Figure 1. The effect of the majority requirement on the voting power, β_i, of the largest five members.

Table 2
The effect of the majority requirement: the power to act and the powers of USA and Japan.

		USA			Japan		
Votes:		17.55			6.30		
Majority Requ q:	PTA	Bz(NN)	PPA	PIA	Bz(NN)	PPA	PIA
50	0.5000	0.7638	0.7638	0.7638	0.1670	0.1670	0.1670
55	0.3609	0.6641	0.9201	0.5196	0.1812	0.2510	0.1418
60	0.2194	0.4315	0.9831	0.2764	0.1802	0.4107	0.1155
65	0.1011	0.2018	0.9982	0.1122	0.1229	0.6079	0.0683
70	0.0316	0.0632	0.9999	0.0326	0.0502	0.7939	0.0259
75	0.0058	0.0116	1	0.0058	0.0108	0.9265	0.0054
80	0.0005	0.0010	1	0.0005	0.0010	0.9845	0.0005
85	1.24473E−05	2.48945E−05	1	1.24474E−05	2.48418E−05	0.9979	1.2421E−05
90	6.7550E−08	1.351E−07	1	6.75502E−08	1.35069E−07	0.9998	6.75345E−08
95	6.4324E−11	1.28668E−10	1	6.43338E−11	1.28665E−10	1	6.43324E−11
100	2.6101E−54	5.2202E−54	1	2.6101E−54	5.2202E−54	1	2.6101E−54

than 75%. The counterpart of the US loss of power is a very small increase in the power of every other member country. The conclusion is that in terms of its share of power within the organisation, as measured by β_1, the use of the special majority rule does not benefit the United States.

The results of computing the Coleman indices for the different majority requirements in the Board of Governors are presented in table 2.[26] Table 2 shows the power to

[26] This analysis has not been done for the Executive Board on the grounds that table 1 showed a similar pattern in both bodies and it was assumed that doing so would provide little additional information.

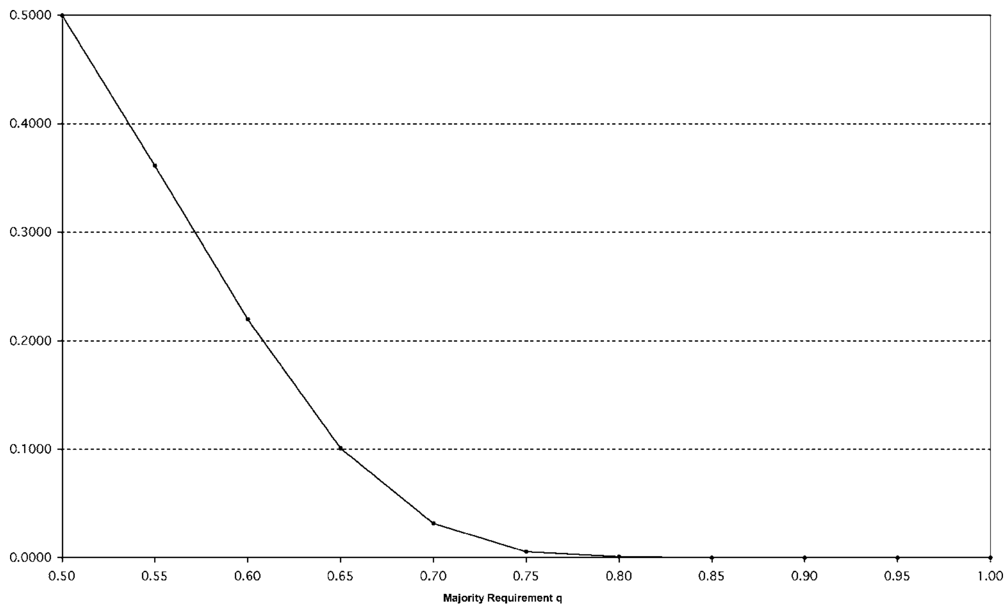

Figure 2. The effect of the majority requirement on the power to act of the Board of Governors.

act, and three power indices, the non-normalised Banzhaf index, the power to prevent action and the power to initiate action, for the top two countries, the USA and Japan.

The results in table 2 for the power to act are graphed in figure 2. This shows that the power to act declines very steeply as the majority requirement increases, becoming almost negligible beyond 75%. This suggests the conclusion that the practice of requiring special majorities is to render the IMF formally relatively ineffective as a democratic decision making body.

Figure 3 shows the Coleman power indices for the largest five countries. The effect of supermajorities on the power of the United States to prevent action is clear but the graph also shows the effect on its power to initiate action which falls to near zero almost as quickly as the former index goes to 1. The non-normalised Banzhaf index, indicating American power over decisions in general, also falls to near zero. A similar pattern is found for the other countries with power to initiate action falling effectively to zero beyond about $q = 0.75$. These results also show that the power to prevent action for all these countries becomes near 1 beyond $q = 0.85$. These findings reflect the central importance of the power to act as a property of a voting body.

Figure 4 graphs the relationship between the indices for the United States and the power to act, for the Board of Governors, from table 2. It suggests there is a common interest between the United States and the IMF in the choice of majority requirement. The point at which US voting power and its power to initiate action are at a maximum is where the Board of Governors' power to act is also a maximum, when $q = 0.5$. This means the US losing its veto but its formal power to prevent action is still quite high at 76%, compared with the corresponding figure for Japan of less than 17%.

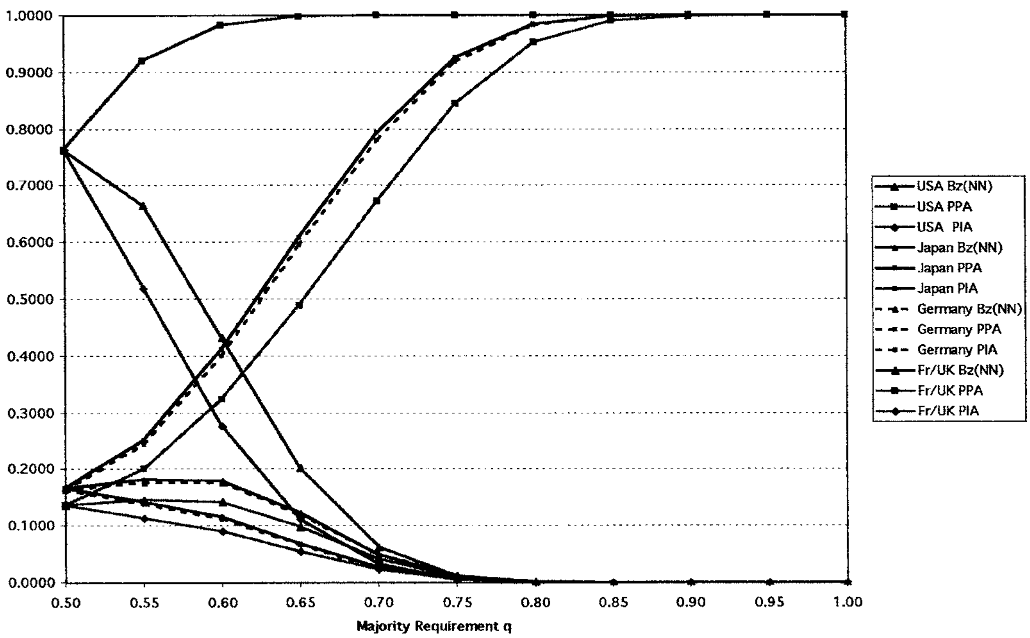

Figure 3. The effect of the majority requirement on Coleman's indices, the power of a Member to Prevent Action and to Initiate Action, and the non-normalised Banzhaf index: Top 5 members.

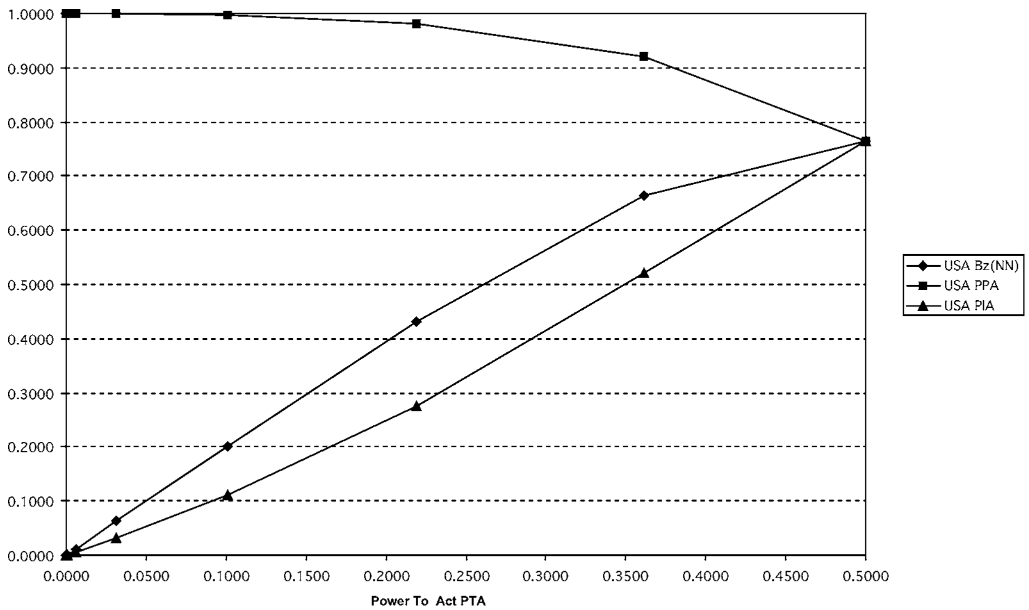

Figure 4. Relationship between US power and the Board of Governors' power to act.

8. An iterative procedure for choosing the weights to achieve a given distribution of power

In designing a system of weighted voting, weights ought to be allocated to members in such a way as to bring about the desired distribution of voting power.[27] Power indices enable this to be done numerically by means of an iterative process by which the weights are successively updated, from an initial guess, and the power indices recalculated until they achieve preassigned values. The values required for the power indices are predetermined as a design property of the voting system.[28]

Let it be required that member i should possess a voting power of d_i, where $\sum d_i = 1$. The problem is to find weights that have associated power indices, β_i, such that $\beta_i = d_i$, for all i. Denote the required power, the weights and corresponding power indices, as functions of the weights, by the vectors d, w and $\beta(w)$.

Let the weights after p iterations be denoted by the vector $w^{(p)}$, and corresponding power indices by the vector of functions $\beta(w^{(p)})$. The iterative procedure consists of an intial guess $w^{(0)}$ and an updating rule:

$$w^{(p+1)} = w^{(p)} + \lambda\big(d - \beta(w^{(p)}\big)$$

for some appropriate scalar $\lambda > 0$. If the procedure converges to a vector, w^*, then that will be the desired weight vector, since then:

$$w^* = w^* + \lambda\big(d - \beta(w^*)\big) \quad \text{and} \quad d = \beta(w^*).$$

Convergence can be defined in terms of a measure of the distance between $\beta(w^{(p)})$ and d and a stopping criterion. The simple sum of squares measure $\sum(\beta_i^{(p)} - d_i)^2$ with a suitable stopping criterion has been found to work well.

9. The choice of weights

Table 3 shows the results of applying the iterative procedure described in the last section to the choice of voting weights in the IMF. The iterative procedure (which has also been used in Leech [21]) was applied here using the algorithm for the Banzhaf index described in Leech [22]; full convergence was achieved with a simple sum of squares distance function and a stopping rule which required it to be less than 10^{-15}. It has

[27] There is some discussion of this issue in Nurmi [24]. An iterative procedure similar to the one described here is proposed in Laruelle and Widgren [18].

[28] For example a natural criterion to use in international organisations is the equalisation of voting power among citizens of different countries; this has been used as a basic principle for the reweighting of votes in the European Union Council of Ministers by Felsenthal and Machover [7]. In the current paper, I use the criterion of equalising power to members' shares in total votes, as given in the Appendix to the IMF Annual Report for 1999, although I do not suggest this to be the only possible approach to the governance of the IMF. It is appropriate since in the IMF Annual Reports, each member's voting weight is referred to as its power and therefore it is of interest to investigate what weights would actually give rise to these powers.

Table 3
The choice of weights.

Executive Board				Board of Governors			
	Banzhaf power	Weight $q = 50\%$	Weight $q = 85\%$		Banzhaf power	Weight $q = 50\%$	Weight $q = 85\%$
USA	17.55	14.9	67.45	USA	17.55	14.06	69.78
Japan	6.3	6.45	2.44	Japan	6.30	6.53	2.20
Germany	6.15	6.3	2.38	Germany	6.15	6.38	2.16
France	5.08	5.23	1.99	France	5.08	5.27	1.82
UK	5.08	5.23	1.99	UK	5.08	5.27	1.82
(Netherlands)	4.98	5.13	1.95	Italy	3.34	3.48	1.23
(Belgium)	4.5	4.64	1.77	Saudi Arabia	3.31	3.45	1.21
(Mexico)	4.36	4.5	1.72	Canada	3.02	3.15	1.11
(Italy)	4.28	4.42	1.69	Russia	2.82	2.94	1.04
(Canada)	3.79	3.92	1.5	Netherlands	2.45	2.56	0.91
(Denmark)	3.59	3.71	1.42	China	2.22	2.32	0.82
(Australia)	3.42	3.54	1.36	India	1.97	2.06	0.73
Saudi Arabia	3.31	3.43	1.32	Switzerland	1.64	1.72	0.61
(Thailand)	3.22	3.33	1.28	Australia	1.54	1.61	0.57
(Angola)	3.19	3.3	1.27	Belgium	1.48	1.54	0.55
Russia	2.82	2.92	1.12	Spain	1.45	1.52	0.54
(Egypt)	2.86	2.96	1.14	Brazil	1.45	1.51	0.54
(Switzerland)	2.67	2.77	1.06	Venezuela	1.27	1.32	0.47
(Brazil)	2.52	2.61	1.01	Mexico	1.23	1.29	0.46
(India)	2.46	2.55	0.98	Sweden	1.14	1.19	0.43
(Iran)	2.45	2.54	0.98	Argentina	1.01	1.06	0.38
China	2.22	2.3	0.89	Indonesia	0.99	1.04	0.37
(Chile)	2.01	2.09	0.8	Austria	0.90	0.94	0.33
(Gabon)	1.19	1.24	0.48	...	...	...	...

Note: The desired powers of the directors in the Executive Board differ slightly from those published which do not sum precisely to 100. Since it is fundamental to the iterative algorithm that power indices are equated to target values, and sum to 1, care must be taken to ensure that the latter also sum to 1, so that convergence is achieved.

been applied to both the Board of Governors and the Executive Board for both ordinary decisions and special majorities. As is to be expected, the resulting weights are very different for the two majority requirements. As before the results for the two bodies are broadly similar.

For ordinary decisions, the voting weight of the United States should be reduced to under 15 percent, and the voting weight of the other member countries increased slightly in order to achieve the levels of voting power given in the appendix to the IMF Annual Report for 1999: United States 17.55, Japan 6.3, Germany 6.15, etc. However for 85% special majority decisions, in order to achieve these values for the power index, the weight of the United States would have to increase to almost 70 percent and those of all other countries reduced substantially.

10. Conclusions

In the introduction I posed four specific questions about voting power in the IMF and have answered them using power indices: how power is distributed; whether the distribution of power is different in the Board of Governors and the Executive Board; what difference the voting majority requirement makes; and what should the voting weights be in order to ensure a given voting power for each member?

I found that, as far as it is possible to make direct comparisons – for the largest five countries which appoint their own directors, and given the bloc votes of the elected directors – the formal distribution of power arising from weighted voting is broadly similar in the two decision making bodies.

On the first question of the extent to which the inequality in voting power is in line with the inequality in the allocation of votes between countries, the main finding is that the USA possesses considerably more power than voting weight in relation to ordinary decisions requiring a simple majority.

The majority requirement was found to have a very strong effect on the distribution of power. The distribution of power in relation to decisions requiring special supermajorities of 85% is relatively equal. While this majority requirement ensures the United States has a veto it also limits that country's power to act within the organisation. I show that there is a clear positive relation between the power to act of the IMF itself and measures of the power of the United States within it, both being maximised for the 50 percent majority requirement. The power to the organisation to act is very sensitive to the majority requirement, falling close to zero for large supermajority requirements.

The fourth question was to find what the weights should be in order to achieve a given desired power distribution. I presented and used a new algorithm for doing this. The results of applying this approach depend crucially on the majority requirement and substantially different voting weights are obtained to give the same power distribution for ordinary and special-majorities decisions.

The general policy implications of this study are, firstly, that the American insistence on setting the special majority requirement so high as to retain its own blocking power is not only damaging to the effectiveness of decision making within the IMF itself but is also counter productive in reducing the influence of the United States as a member, in terms of formal voting power. Secondly, votes should be allocated to individual members instrumentally to achieve the required distribution of voting power.

Acknowledgments

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References

[1] J.F. Banzhaf, Weighted voting doesn't work: A mathematical analysis, Rutgers Law Review 19 (1965) 317–343.

[2] S.J. Brams, *Game Theory and Politics* (Free Press, 1975).

[3] J.S. Coleman, Control of collectivities and the power of a collectivity to act, in: *Social Choice*, ed. Lieberman (Gordon and Breach, 1971) pp. 277–287.

[4] J.S. Dreyer and A. Schotter, Power relationships in the IMF: the consequences of quota changes, Review of Economics and Statistics 62 (1980) 97–106.

[5] Dubey and L.S. Shapley, The mathematical properties of the Banzhaf index, Mathematics of Operations Research 4 (1979) 99–131.

[6] D.S. Felsenthal and M. Machover, *The Measurement of Voting Power: Theory and Practice, Problems and Paradoxes* (Edward Elgar, 1998).

[7] D.S. Felsenthal and M. Machover, Enlargement of the EU and weighted voting in its Council of Ministers, LSE Voting Power Programme Report, VPP 01/00, Centre for the Philosophy of Natural and Social Sciences, London School of Economics (2000).

[8] G. Garrett and G. Tsebelis, An institutional critique of intergovernmentalism, International Organization 50 (1996) 269–299.

[9] G. Garrett and G. Tsebelis, Why resist the temptation of power indices in the EU?; and more reasons to resist the temptation of power indices in the EU, Journal of Theoretical Politics 11(3) (1999) 291–308 and 331–338.

[10] J. Gold, Voting and decision in the International Monetary Fund: An essay on the law and practice of the fund, IMF, Washington DC (1972).

[11] J. Gold, Weighted voting power: Some limits and some problems, American Journal of International Law 68 (1972) 702–804.

[12] J. Gold, The origins of weighted voting power in the fund, Finance and Development (March 1981) 25–28.

[13] M. Hosli, The admission of the European Free Trade Association States to the European Economic Community, International Organization 47 (1993) 629–643.

[14] M. Hosli, An institution's capacity to act: What are the effects of majority voting in the Council of the EU and in the European Parliament?, European Institute of Public Administration (1998).

[15] J.M. Keynes, Speech to House of Lords, 18 May 1943, in: *The Collected Writings of John Maynard Keynes*, ed. D. Moggridge, Vol. XXV (Cambridge University Press, 1980) p. 278.

[16] J.M. Keynes, Letter to J. Viner, 12 July 1943, in: *The Collected Writings of John Maynard Keynes*, ed. D. Moggridge, Vol. XXV (Cambridge University Press, 1980) p. 328.

[17] J.-E. Lane and S. Berg, Relevance of voting power, Journal of Theoretical Politics 11(3) (1999) 309–319.

[18] A. Laruelle and M. Widgren, Is allocation of voting power among EU states fair?, Public Choice 94 (1998) 317–339.
[19] D. Leech, Power relations in the International Monetary Fund: A study of the political economy of a priori voting power using the theory of simple games, Centre for the Study of Globalisation and Regionalisation, University of Warwick, CSGR Working Paper No. 06/98 (revised March 2000).
[20] D. Leech, An empirical comparison of the performance of classical power indices, Political Studies 50(1) (March 2002) 1–22.
[21] D. Leech, Designing the voting system for the Council of the European Union, Public Choice, forthcoming. Earlier versions as a working paper under the title, "Fair reweighting of the votes in the EU Council of Ministers and the choice of majority requirement for qualified majority voting during successive enlargements", at Voting Power and Procedures programme, CPNSS, London School of Economics, VPP03/01 and Centre for the Study of Globalisation and Regionalisation, University of Warwick, CSGR Working Paper No. 75/01.
[22] D. Leech, Computing power indices for large weighted voting games, Warwick Economic Research Papers, No. 579, University of Warwick (revised July 2001).
[23] W.F. Lucas, Measuring power in weighted voting systems, in: *Political and Related Models*, eds. S. Brams, W. Lucas and P. Straffin (Springer, 1983).
[24] H. Nurmi, The problem of the right distribution of voting power, in: *Power, Voting and Voting Power*, ed. M.J. Holler (Physica-Verlag, 1981).
[25] G. Owen, *Game Theory*, 3rd edn. (Academic Press, 1995).
[26] L.S. Penrose, The elementary statistics of majority voting, Journal of the Royal Statistical Society 109 (1946) 53–57.
[27] A.E. Roth, *The Shapley Value* (Cambridge University Press, 1988).
[28] O. Sadako, Shifting power relations in Multilateral Development Banks, The Journal of International Studies (Institute of International Relations, Sophia University, Tokyo) 22 (January 1989) 1–25.
[29] L.S. Shapley and M. Shubik, A method for evaluating the distribution of power in a committee system, American Political Science Review 48 (1954) 787–792.
[30] P.D. Straffin, Power and stability in politics, in: *Handbook of Game Theory*, Vol. 2, eds. R.J. Aumann and S.J. Hart (Elsevier, 1994) pp. 1128–1151.
[31] J.R. Strand, D.P. Rapkin and D.B. Wood, The political economy of a priori voting power in the World Bank and IMF, Mimeo (1997).
[32] S. Zamora, Voting in International Economic Organizations, American Journal of International Law 74 (1980) 566–608.