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## Measures for Measures: Evaluating Judgements of Donor Allocative Performance

Edward Anderson and Paul Clist

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## **Abstract**

This paper reviews the various measures which have been used in the recent literature to assess how well donors allocate their aid across countries. We begin by proposing three desirable criteria for a measure of allocative performance, which make only limited assumptions about the features of an ideal aid allocation. We then show that all existing measures of allocative performance fail to meet these criteria. We go on to propose a new measure that does meet our criteria, and present rankings of the allocative performance of the 23 OECD-DAC bilateral donors on the basis of this measure. The ranking differs quite substantially from those based on existing measures.

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## 1 Introduction

How well do donors allocate aid across countries? Various measures have been used to try to answer this question, which are often used to rank donors. Recent examples include the headcount measure (Easterly and Pfutze 2008; Easterly and Williamson 2011), the Suits index (Baulch 2006), the correlation coefficient (Nunnenkamp and Thiele 2006), regression coefficients (Easterly 2007, Knack et al. 2011), and specially designed performance indices (McGillivray 1989, 1992; Rao 1994, 1997; Roodman 2006; Birdsall and Kharas 2010). We now face an increasingly wide variety of measures, which do not point in the same direction. This raises the question of which – if any – of these measures can be considered a good measure of how well donors allocate their aid across countries – what may be termed their ‘allocative performance’ (White and McGillivray 1995: 164).

One way to address this question is to propose criteria that a good measure of allocative performance should meet; any measure which fails to meet one or more criteria can then be rejected. Examples of this approach include White and McGillivray (1995) and Rao (1994, 1997). In developing their criteria, these authors take the position that aid should be allocated according to country ‘need’ alone, with country need being measured primarily by income per capita.<sup>1</sup> This position may be challenged for two reasons. First, income per capita is a very limited measure of need. Even if we accept the argument that income per capita is highly correlated with other welfare measures, and that income distribution data are problematic (e.g. White and McGillivray 1995: 165-166; Rao 1994: fn 1), it seems hard to deny that a country’s need for aid also depends on the size of its population, as well as its income per capita. Second, many people now take the view that aid should be allocated according to the quality of recipient country policies, institutions and governance – hereafter, just ‘policy’ – as well as country need. The argument is that aid is more effective at reducing poverty in countries with better policy, so that allocating relatively more aid to such countries will raise the total amount of poverty reduction achieved by aid (e.g. Collier and Dollar 2001, 2002). Although the

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<sup>1</sup> For example, White and McGillivray (1995) state that “[the point] is not that aid *is* allocated on income grounds alone, but (implicitly) that it should be. ... [We] will evaluate donor performance from this perspective.” (ibid: 165). Similarly, Rao (1994: 1579) states that allocative performance – referred to as the ‘quality of aid’ – is “restricted to a single dimension *viz.* how well an aid giver’s allocation conforms to the revealed need of aid recipients. Need is measured solely in terms of realized per capita income”. The position is also adopted by McGillivray (2004: 276), who argues that “[allocative] performance is ... an increasing function of the consistency of inter-recipient aid allocation with the relative needs of recipients. The greater the preference given to needy countries, the greater is donor performance. Need can of course be defined in a number of ways, but it is generally accepted that poor countries, with low per capita income, are the most needy.”

econometric evidence in support of this argument remains controversial – see for example Easterly et al. (2003) – the viewpoint has become increasingly widespread.

In this paper therefore we aim to develop new criteria for a determining a good measure of allocative performance. In Section 2 we propose three related criteria, referred to as income, population and policy sensitivity. Income sensitivity requires that a reallocation of aid from a poorer to a richer recipient (in terms of income per capita) should worsen a performance measure, *ceteris paribus* – i.e. if the two recipients have the same (initial) levels of population, policy and aid. Population sensitivity requires that a reallocation from a larger to a smaller recipient (in terms of population) should worsen a performance measure, *ceteris paribus* – i.e. if the two recipients have the same (initial) levels of income per capita, policy and aid. Finally policy sensitivity requires that a reallocation from a recipient with better policy to one with worse policy should worsen performance, again *ceteris paribus* - i.e. if the two recipients have the same initial levels of income per capita, population and aid.

If we believe that aid should be allocated according to country need alone, then a measure should satisfy income and population sensitivity – since both income and population affect country need – but not policy sensitivity. If we believe that aid should be allocated according to country policy as well as need, then a measure should meet all three criteria. However, we show in Section 3 that none of the existing performance measures used in the literature meets all three criteria, while only one meets both income and population sensitivity. This leads us to propose, in Section 4, a new measure which does meet all three of our criteria. This measure is related to the performance indices proposed by McGillivray (1989, 1992) and Roodman (2006), but departs from these indices by taking policy and population into account, alongside income per capita, rather than just policy or population. We go on to show that this measure generates quite different rankings of donors to existing measures. Thus its advantage in terms of meeting desirable criteria is of practical importance.

Our concern in this paper is limited to donors' allocative performance, which is just one component of their overall performance. Measures of overall donor performance are increasingly common in the literature, beginning with Roodman (2006) and including more recently Easterly and Pfutze (2008), Knack et al (2011), Birdsall and Kharas (2010), and Easterly and Williamson (2011). These studies assess various dimensions of donor performance, such as the amount of aid that is tied, the share of aid spent on administration costs, and combine performance in each dimension into an overall performance score or ranking. However, the results in this paper suggest that the measures of allocative performance used to construct these overall performance indices do not meet certain basic criteria for a good performance measure. This leads us to question the validity of existing indices of overall donor performance, and the rankings of donors they generate.

## 2 Desirable criteria for measures of allocative performance

What is a good measure of an aid donor's allocative performance? White and McGillivray (1995) and Rao (1994, 1997) address this question by defining a set of criteria that a measure of allocative performance should meet, and then identifying measures which meet these criteria. In this section we begin by challenging some of the criteria proposed by these authors. We then go on to propose three new criteria.

Before proceeding, it is helpful to discuss briefly what we mean by a recipient country's 'need' for aid, and how this can be measured. Arguably, the need for aid reflects both the amount of poverty and the availability of domestic resources for tackling poverty (with a positive relationship in the former case and a negative relationship in the latter). Neither of these things is particularly easy to measure. The most obvious proxy is income per capita, which can serve as a proxy for the *average* level of poverty in a country – e.g., the proportion of the population living on less than \$1-a-day – and the availability of domestic resources for tackling poverty (with a negative relationship in the former case and a positive relationship in the latter). One problem is that there is often only a weak relation between income per capita and the average level of poverty. The counter-argument, however, is that the data required to construct better measures of average poverty (typically, derived from household surveys) are themselves problematic: for example, they are not always available (e.g. White and McGillivray 1995: 165-166; Rao 1994: fn 1). In developing our criteria, we adopt this same argument and use income per capita as a proxy for the average poverty level.<sup>2</sup>

Another problem with income per capita is that country need reflects not just the average level of poverty, but the *aggregate* level: e.g., the number of people living on less than \$1-a-day, and not just the proportion of the population. For although there may be some economies of scale in tackling poverty, most people would accept that a recipient with (say) 100 million people living on less than \$1-a-day needs at least some more aid than another with 10 million people living on less than \$1-a-day, even if the proportion of the total population in each case is the same. For this reason, we develop our criteria under the assumption that country need depends on population as well as income per capita. In algebraic terms, our position may be summarised as:

$$need = f(y, N) \tag{1}$$

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<sup>2</sup> This is not to deny that direct poverty measures, e.g. the World Bank \$1-a-day poverty estimates, have become much more widely available and accessible since the time in which White and McGillivray (1995) and Rao (1994, 1997) were writing. Despite this, all but one of the recent studies assessing donor allocative performance listed in the Introduction continue to rely on income per capita as a proxy for poverty; only one (Baulch 2006) uses more direct measures.

where  $y$  is income per capita and  $N$  is population. Equation (1) is deliberately written in a very general form, with the only assumption being that country need for aid is decreasing in income per capita and increasing in population.<sup>3</sup>

## 2.1 Existing proposals

White and McGillivray (1995) outline four criteria for a good performance measure, namely:

- regressive reallocations must not improve a performance measure;
- a performance measure should not be maximised by giving all aid to a single recipient;
- no anti-concentration bias, meaning that a performance measure should not penalise donors for failing to give aid to all recipients;
- scale neutrality, meaning that a performance measure should not be affected by the scale of the aid programme.

Rao (1994, 1997) outlines three criteria, namely:

- vertical equity, meaning that progressive reallocations must improve performance;
- horizontal equity, which requires that any two recipients with the same income per capita receive the same amount of aid per capita;
- neutrality, which is defined in the same way as scale neutrality above.

Consider the first criterion proposed by White and McGillivray. A regressive reallocation refers to a reallocation of aid from one recipient  $n$  to another recipient  $m$ , where  $m$  has higher income per capita than  $n$ . The authors justify this criterion with reference to the so-called Dalton condition, which states that a progressive (regressive) reallocation between two individuals should always improve (worsen) an inequality measure, as long as it does not reverse their relative positions (Dalton 1920; see also Sen 1973). However, while the Dalton principle may make sense when applied to individuals, it is not obvious that it also applies in the present context. If we believe that aid should be allocated according to country need alone, then we might argue that a reallocation from one recipient with higher need to another with lower need should not improve performance. But to argue that a reallocation from a recipient with higher income per capita to another with lower income per capita should never improve performance makes sense only if we assume that country need

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<sup>3</sup> By decreasing in income per capita, we mean that for any two recipients  $m$  and  $n$  with the same population,  $y_m < y_n$  implies  $need_m > need_n$  (and vice versa). Similarly, by increasing in population we mean that for any two recipients  $m$  and  $n$  with the same income per capita,  $N_m > N_n$  implies  $need_m > need_n$  (and vice versa). Note that income per capita in equation (1) serves as a proxy for the availability of domestic resources for tackling poverty, as well as the average poverty level.



is completely determined by income per capita, and insensitive to population.<sup>4</sup> As already noted, this does not seem plausible – since a country with higher income per capita could, if its population size is much larger, have a higher need for aid. Thus even if we believe that aid should be allocated according to country need alone, this first criterion proposed by White and McGillivray (1995) does not on reflection seem that desirable.

Now consider the criterion of vertical equity proposed by Rao (1994, 1997). This states that a progressive reallocation – i.e., a reallocation from recipient  $n$  to another recipient  $m$ , where  $m$  has lower income per capita than  $n$  – must always improve performance.<sup>5</sup> Again, if we believe that aid should be allocated according to country need alone, then we might argue that a reallocation from a recipient with lower need to another with higher need must always improve performance. But we can only argue that a progressive reallocation must always improve performance if we again assume that country need depends only on income per capita, and is completely insensitive to population. Thus the criterion of vertical equity is not in fact desirable – even if we believe that aid should be allocated according to country need alone.

Finally, consider the criterion of horizontal equity proposed by Rao (1994, 1997). This requires that any two recipients with the same income per capita should receive the same amount of aid per capita.<sup>6</sup> If we believe that aid should be allocated according to country need alone, then we might argue that two recipients with the same income per capita should receive the same aid per capita, but only if we assume that country need rises proportionately with population: i.e. if one recipient has twice the population of another, but the same level of income per capita, it needs twice the amount of aid. In other words, we would need to re-write equation (1) as:

$$need = h(y) \cdot N \tag{2}$$

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<sup>4</sup> In algebraic terms, we would need to re-write equation (1) as:  $need = g(y)$ .

<sup>5</sup> Here it is worth noting that Rao's description of 'vertical equity' is somewhat ambiguous, as it is not clear whether a progressive reallocation must always raise an index for this criterion to be satisfied, or if it is sufficient that it sometimes does so: "[v]ertical equity is satisfied if a reallocation of aid from a richer recipient to a poorer one raises the value of the index of equity." (1994: 1579). Here we assume that vertical equity requires that a progressive reallocation must always improve performance, although we build on the idea of requiring that a progressive reallocation improves performance in certain circumstances, but not all, in Section 2.2.

<sup>6</sup> Here it is worth noting that the principle of horizontal equity defined by Rao refers to a feature of the allocation of aid: "[a]s between two recipients with identical per capita incomes, horizontal equity requires that per capita aid be equalized. Thus, the equal treatment of equally poor recipients demands that total aid should differ proportionately with their populations." (Rao 1994: 1579) Thus if this principle is accepted, we would need to ask what criteria a performance measure should therefore meet. As explained in the main text however, the principle may not be widely accepted.

Although plausible, there are no grounds in theory or in the empirical evidence to suggest that the need for aid does rise proportionately with population. It is equally plausible to argue that country need rises less than proportionately with population, because of economies of scale: i.e., if one recipient has twice the population of another, but the same income per capita, it needs more aid but not twice as much.<sup>7</sup> Thus the criterion of horizontal equity also fails to appear that desirable.

Thus the ‘regressive reallocations must never improve performance’ criterion proposed by White and McGillivray (1995), and the criteria of vertical and horizontal equity proposed by Rao (1994, 1997), do not on closer inspection appear to be that desirable. In particular, they are based on assumptions regarding the determinants of country need: that need is completely insensitive to population, or that country need rises proportionately with population – that are not well grounded in either theory or evidence. This leads us to doubt the criteria, even if we believe that aid should be allocated according to country need alone. If we believe that aid should be allocated according to country policy as well as need, then the criteria become even less desirable. For example, a progressive reallocation to a recipient with worse policy might be considered to worsen allocative performance – thus further undermining the appeal of the ‘vertical equity’ criterion. Similarly, a regressive reallocation to a recipient with better policy might be considered to improve allocative performance – thus further undermining the appeal of the ‘regressive reallocations must not improve performance’ criterion.

The other criteria proposed by White and McGillivray (1995) and Rao (1994, 1997) may also be debated, but this is not our intention here. Instead, our aim is to develop new criteria which avoid the problems with the three criteria discussed above.

## 2.2 Three new criteria

In this section we propose three new criteria that a measure of allocative performance should meet. The first criterion is ‘income sensitivity’. The idea here is that rather than requiring that a progressive (regressive) reallocation should always improve (worsen) a performance measure, it should do so *ceteris paribus*. More specifically, if two recipients have the same initial levels of population, policy and aid, but different levels of income per capita, then:

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<sup>7</sup> As is well known, there is a clear tendency in actual allocation patterns for smaller countries to receive less aid on a per capita basis than larger countries, a phenomenon known as small country bias (e.g. Isenman 1976). In the literature on this issue, it is recognised that there are reasons why donors should give at least some more aid on a *per capita* basis to smaller countries than to larger countries: Isenman (1976) discussed economies of scale in technical assistance, while White (2004) refers to the fixed costs of country aid programmes. Thus even if we regard the current amount of small country bias in allocation patterns as excessive, we would not necessarily require that larger countries receive the same amount of aid on a per capita basis than smaller countries.

- a regressive reallocation must worsen performance, and
- a (rank-preserving) progressive reallocation must improve performance.

We focus on rank-preserving reallocations in the latter case to avoid the ‘leap-frogging’ problem, i.e. the possibility that a progressive reallocation of aid from a richer to a poorer recipient causes a reversal of their relative positions. The criterion of income sensitivity is designed to have wide appeal. It makes only two assumptions: that country need is decreasing in income per capita, and that optimal aid is increasing in country need.<sup>8</sup> The justification is as follows. If country need is decreasing in income per capita, and if two recipients have the same population, then the one with higher (lower) income per capita will have a lower (higher) need for aid. If optimal aid is increasing in country need, and two recipients have the same policy, then the one with lower (higher) need should receive less (more) aid. Thus starting from a position in which two recipients receive the same amount of aid, a (rank-preserving) progressive reallocation should improve performance, and a regressive reallocation should worsen it.<sup>9</sup>

The second criterion we propose is ‘population sensitivity’. This requires that if two recipients have the same (initial) levels of income per capita, policy and aid, but different levels of population, then:

- a reallocation to the smaller recipient must worsen performance, and
- a reallocation to the larger recipient must improve performance.

This criterion makes just one further assumption: that country need is increasing in population. The justification is very similar. If country need is increasing in population, and two recipients have the same initial level of income per capita, the one with higher (lower) population will have a lower (higher) need for aid. If the two recipients also have the same policy, then the one with lower (higher) need should receive less (more) aid. Thus starting from a position in which they both receive the same amount of aid, a reallocation to the smaller recipient should worsen performance, and reallocation to the larger recipient should improve it.

One possible objection is that a reallocation between two recipients with the same initial level of income per capita will cause one to become richer than the other. Thus

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<sup>8</sup> By increasing in country need, we mean that for any two recipients  $m$  and  $n$  with the same level of policy,  $need_m > need_n$  implies  $A^*_m > A^*_n$  (and vice versa), where  $A^*$  is optimal aid.

<sup>9</sup> A stronger version of this criterion could be considered, which would simply drop the requirement that two recipients have the same policy. This would appeal to anyone who believes that aid should be allocated according to country need alone, although not to those who believe that aid should be allocated according to country policy as well as need. The criterion is somewhat flexible therefore, although for our purposes it is sufficient to focus on the version stated in the main text. The same also applies to the criterion of population sensitivity.

a reallocation to the larger recipient might not be considered to improve performance, since a richer country will end up receiving more aid than a poorer country, in terms of their levels of income per capita following the reallocation. This objection can be avoided if we focus only on the first part of the criterion, i.e. that a reallocation to the smaller recipient must worsen performance. The reason is that if the smaller recipient becomes richer as a result of the reallocation, this reinforces the view that the reallocation should worsen performance.

The third new criterion we propose is 'policy sensitivity'. This requires that if two recipients have the same initial levels of population, income per capita and aid, but different policy, then:

- a reallocation to the recipient with worse policy must worsen performance, and
- a reallocation to the recipient with better policy must improve performance.

This third criterion is designed to appeal to anyone who believes that aid should be allocated according to country policy as well as need. It makes just one further assumption: that optimal aid is increasing in the quality of policy. The justification is as follows. If two recipients have the same levels of income per capita and population, they have the same level of need. If optimal aid is increasing in the quality of policy, and two recipients have the same level of need, then the recipient with better policy should receive more aid. Thus starting from a position in which the two recipients have the same initial amounts of aid, a reallocation to the recipient with better policy should improve performance. As with 'population sensitivity', the potential objection based on the sensitivity of income per capita to aid can be avoided if we focus only on the first part of the criterion.

Overall, the three criteria – income, population and policy sensitivity – are of wide appeal, since they are based on only limited assumptions regarding the features of an ideal aid allocation. The first two assume only that optimal aid is increasing in country need, and that country need is decreasing in income per capita and increasing in population. If we accept these assumptions, then we should reject any measures which do not satisfy income or population sensitivity. If we believe that optimal aid is increasing in country policy as well as need, then we should also reject any measures which do not satisfy policy sensitivity. In this way, the criteria provide a basis for assessing the merits of the various performance measures used in the recent literature. This is the aim of the next section.

Of the themes touched on in pre-existing criteria, one issue we don't address is the issue of specialisation. Country specialisation is a common practice by donors, and one that is considered reasonable from the point of view of reducing aid fragmentation. It can however greatly complicate assessments of allocative performance. Consider, for example, the hypothetical allocation shown in Table 1, with two donors (A and B) and two recipients (X and Y). Donor A gives relatively

more aid to the richer recipient X, while donor B gives relatively more aid to the poorer recipient Y. This pattern of specialisation is in turn based on A having a 'comparative advantage' in giving aid to recipient X (e.g. a common language, or geographical proximity). The problem is that, if patterns of specialisation of this sort are considered reasonable, in terms of reducing transaction costs, then we cannot expect each individual donor's aid to be increasing in country need, and the justification for our criteria no longer holds.

The reason we abstract from the issue of specialisation is that, from a purely allocational perspective, it is desirable that each donor's aid is increasing in country need and, if considered relevant, policy. If donors specialise, this represents an improvement in a separate dimension of their performance, which offsets any deterioration in their measured allocative performance. In other words, we treat specialisation, like other sources of transaction costs, as something separate from our topic here: allocative performance. Most existing indices of overall donor performance do reward donors for country specialisation, and so this approach makes sense. Moreover, although our focus in this paper is on assessing individual donor performance, this potential objection would not apply if our concern was to assess the collective performance of all donors, since in this case issues of specialisation do not arise.

### **3 Existing performance measures: a re-assessment**

In this section we examine the various measures which have been used in the recent literature to assess allocative performance, from the perspective of the three new criteria set out in Section 2. We follow White and McGillivray (1995) in considering five types of measures, namely: headcount measures, the Suits index, correlation coefficients, regression coefficients, and performance indices. To determine whether a particular measure meets our criteria, we follow the approach set out by Rao (1994). We first derive algebraically the response of the measure to a small (marginal) reallocation of aid from one recipient to another, with aid to all other recipients held constant. We then examine the properties of this response (e.g. whether it is always positive or always negative) depending on the type of reallocation (e.g. if regressive or progressive). On the whole we simply summarise the main findings in the main text; the underlying derivations are shown in Annex 1.<sup>10</sup>

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<sup>10</sup> It is possible that a measure meets our criteria when considering only small reallocations of aid, but not when considering large reallocations. This would be worth exploring if several measures do meet our criteria when considering only small reallocations, since it would then be of interest to know which of these measures also meet our criteria when considering large reallocations. As it happens, no existing measure meets all of our criteria, even when considering only small reallocations.

In implementing this approach, we assume that aid has no impact on per capita income, what Rao (1994, 1997) calls the ‘invariance postulate’. This requires some justification, since the assumption is considered implausible by Rao. First, we refer here only to the immediate impact of aid, i.e. its impact on recipient income in the year in which it is given (and received); we do not assume that aid has no impact on per capita income over the medium or long-term. Second, we refer here only to the impact of small (marginal) reallocations of aid, and not to large reallocations which clearly are more likely to affect recipient income. Third, in the absence of more formal analysis it is difficult to say more precisely what the effect of aid on per capita income will be. Rao (1994, 1997) argues that it makes more sense to assume that aid translates one-to-one into recipient income, i.e. each dollar of aid causes recipient income to rise by one dollar, what he calls the ‘additivity postulate’. But although it is possible that aid translates one-to-one into income, there are no obvious grounds for thinking that it will do.<sup>11</sup> Thus it is not completely implausible to argue that a small reallocation of aid has no immediate impact on per capita income in the affected countries, and other assumptions (e.g. that aid immediately raises income on a one-to-one basis) are not obviously more plausible. We do however recognise that the results derived in this section do not necessarily hold under alternative assumptions regarding the impact of aid and income.

### 3.1 The headcount

The simplest measure of allocative performance is the headcount measure: the proportion of aid which goes to a particular group of recipients. Recent studies which use headcount measures include Nunnenkamp and Thiele (2006), Easterly and Pfutze (2008) and Easterly and Williamson (2011). The headcount has also been used as a performance measure by donors themselves; for example, the UK has adopted targets to allocate a certain proportion of its aid to low income countries (LICs).<sup>12</sup>

One problem with the headcount arises when there are changes in the population shares of the groups under consideration. For example, Nunnenkamp and Thiele (2006) show that the share of aid allocated to the poorest 25% of countries fell

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<sup>11</sup> Here it is important to be clear about what we mean by income. If we mean GDP or GNP, then income may well rise as a result of an aid inflow, but we have no grounds for thinking that the effect will be one-to-one. By contrast, if we mean Disposable National Income (DNI), then income will rise automatically following an aid inflow, since aid (at least that provided in grant form) is a component of DNI. If the aid inflow has no impact on GDP or GNP, then the impact on DNI will be one-to-one, but if the inflow does have an impact on GDP or GNP, its impact on DNI will be more than one-to-one. Thus however we define income, there are no obvious grounds for assuming that aid has a one-to-one impact on income.

<sup>12</sup> For example, the UK Department for International Development Public Service Agreements for 2003-06 and 2005-08 set out a target of 90% of aid going to LICs; in the 1999-2002 PSA, the target was 75%.

between 1981-86 and 1999-2002, a trend which would normally represent a decline in allocative performance. But the population share of the poorest 25% of countries also fell over the period, as China and India graduated from this group. One could argue therefore that donors were right to allocate a smaller proportion of their aid to the poorest 25% of countries in 1999-2002 than in 1981-86.<sup>13</sup> For this same reason, measuring performance by the share of aid allocated to LICs is problematic, since the population share of this group has also fallen rapidly, even when excluding India and China.<sup>14</sup>

More relevant in the context of this paper, the headcount measure fails to meet all three of our criteria. For example, if the headcount measure is defined by income per capita, then a progressive (regressive) reallocation will improve (worsen) performance if the two recipients are in separate groups. But if they belong to the same group, a reallocation between them will have no effect on the headcount measure – and so none of income, population and policy sensitivity are satisfied. The same applies if the headcount is defined by a measure of policy. The failure of the headcount to satisfy our criteria stems from its well-known insensitivity to changes in allocation within each specified group (White and McGillivray 1995: 175), and so should not be of any particular surprise. Thus while the headcount may well continue to be used because of its simplicity, it fails to meet our criteria for a good performance measure.

### 3.2 The Suits index

The Suits index is best illustrated graphically, via the use of an aid concentration curve. As normally defined, an aid concentration curve is a graph showing the cumulative share of successive recipients in total aid against the cumulative share of each recipient in total population, with the groups being ranked from lowest to highest level of income per capita (see Figure 1). The Suits index is then defined as the ratio of the area A (which is multiplied by -1 if lying above the 45-degree line) to the area B. The value of the index varies from -1 to +1, with negative values closer to 1 indicating increasing concentration of aid on the lower ranked countries, i.e. better performance.

Recent studies which have calculated aid concentration curves and the Suits index include Berthelemy and Tichit (2004) and Baulch (2006). The study by Baulch (2006) is of particular interest since this uses measures of aggregate poverty rather than total population. Four different concentration curves and associated Suits indices are compared, corresponding to four different measures of aggregate poverty: the

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<sup>13</sup> Nunnenkamp and Thiele (2006) recognise this problem, but argue that the evidence of declining poverty orientation (in the form of declining share of aid to the poorest 25% of countries) remains if India and China are excluded from the analysis, at least for multilateral donors.

<sup>14</sup> For a detailed discussion of this trend and its wide-ranging implications see Sumner (2010).

number of people living on less than \$1-a-day; the number of under-weight children; the number of children not enrolled in school, and the number of child deaths.

The Suits index is much better than the headcount at dealing with changes in the share of total population (or aggregate poverty) made up by different groups of recipients. The aid concentration curve also provides a highly useful graphical device, with its shape quickly revealing certain important features of donors' allocation practices, such as the much lower allocations of aid on a per capita basis to large countries, particularly India and China. Despite these advantages, the Suits index does not perform well against our criteria. If recipients are ranked in terms of income per capita, then a progressive reallocation will always improve the Suits index, and a regressive reallocation will always worsen it (see Annex 1.2). This means that income sensitivity is satisfied. But if two recipients have the same level of income per capita, their ranking is indeterminate, and so a reallocation between them (e.g. from a smaller to a larger recipient) could impact the index in either direction. This means that neither population nor policy sensitivity are satisfied. This problem could be rectified, if countries were ranked in terms of a composite indicator which reflects both income per capita and population – in which case the index would satisfy income and population sensitivity – or income per capita, population and policy, in which case it would also satisfy policy sensitivity. Until now however, the Suits index has always been calculated using income per capita as the only ranking variable.

### **3.3 The correlation coefficient**

A third measure which has been used to evaluate allocative performance is the correlation coefficient. Typically, this is calculated between some measure of the amount of aid received by each recipient – e.g. aid as a share of a donor's total aid, or aid per capita – and some measure of the need of each recipient, e.g. income per capita. The coefficient varies between -1 and +1, with lower (i.e. more negative) values indicating better performance. The Spearman rank coefficient is often preferred, on the grounds that it allows for non-linear relationships between aid and the indicator of need. Although common in the early descriptive literature (White and McGillivray 1995: 167), the correlation coefficient has been used much less in more recent studies. One recent exception is Nunnenkamp and Thiele (2006), who calculated the Spearman rank correlation coefficient between the amount of aid per capita received by each recipient, and their level of income per capita, for all DAC donors and all multilateral donors, as well as for nine major bilateral donors, in 1981-86 and 1999-2002.

This rather limited use of the correlation coefficient reflects its perceived drawbacks as a performance measure. According to White and McGillivray (1995: 170), the most serious drawback of the correlation coefficient is its insensitivity to the progressivity of the aid allocation. In terms of the criteria developed in this paper, the drawback is



that being a measure of association between just two variables, the correlation coefficient satisfies at most only one of our three criteria. For example, the correlation coefficient between aid and income per capita satisfies income sensitivity, but fails to satisfy policy and population sensitivity, irrespective of how aid is measured, i.e. whether in logged (value) terms, or in per capita terms, or as a share of the donor's total aid (see Annex 1.3).<sup>15</sup> Thus the correlation coefficient also fails to satisfy our criteria for a good performance measure.

### 3.4 Regression coefficients

In their review, White and McGillivray (1995) discussed the use of the slope coefficient from a simple bivariate regression of income per capita on aid per capita as a performance measure. The lower (i.e. more negative) this coefficient, the better is allocative performance. More recent studies have gone on to use coefficients obtained from multiple regressions. For example, Easterly (2007, Tables 2-11) regresses the log of aid on per capita income and population and later on per capita income, population and various policy indicators. He then uses the slope coefficients for per capita income and the policy indicators to assess whether donors have become more responsive to recipient country need and performance in recent years. Knack et al. (2011) estimate a similar regression with three explanatory variables – the World Bank CPIA index, per capita income and population – and construct an aid selectivity index equal to the unweighted average of the standardised values of the coefficients on income per capita (multiplied by -1) and the CPIA index.

The relevant question here is whether the coefficients estimated by these authors represent good performance measures – either individually or when combined into an average – according to the criteria developed in Section 2.<sup>16</sup> We focus only on regression coefficients estimated by the method of ordinary least squares, and on regressions with aid measured in logged value terms or as a share of a donor's total aid.<sup>17</sup>

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<sup>15</sup> Recall that in this paper we are considering only small (marginal) reallocations of aid (cf fn 10). It is possible to demonstrate that a large regressive reallocation can improve performance as measured by the correlation coefficient, *ceteris paribus*; thus the correlation coefficient satisfies income sensitivity in a limited sense only.

<sup>16</sup> Viewed as econometric studies, the models estimated by Easterly (2007) and Knack et al. (2010) might be considered mis-specified, since they omit various other factors which affect aid allocations, such as former colonial status and commercial ties, which may be correlated with income per capita, policy and/or population. This point was made by McGillivray and White (1993) in relation to a number of earlier empirical studies of aid allocation using regression analysis.

<sup>17</sup> We do not consider regressions with aid measured in per capita terms since in this case the coefficients do not satisfy scale neutrality (White and McGillivray 1994: 170-171).

The first point worth noting is that the effect of a reallocation of aid on the value of a regression coefficient depends on the values of the explanatory variables included in the regression. This means that we can either require that a regression coefficient meets our criteria in a ‘strong’ sense, i.e. irrespective of what the values of the explanatory variables happen to be, the criteria will always be met; or in a ‘weak’ sense, i.e. given current prevailing values of the explanatory variables, the criteria happen to be met, but we cannot be sure they will continue to be met as the values of each explanatory variable change over time. Clearly, it is more desirable that a measure meet the criteria in the strong sense and not simply the weak sense.

Consider first a simple bivariate regression between aid and income per capita. As might be expected – given that measures of population and policy are not included – the estimated slope coefficient from this regression satisfies income sensitivity but fails to satisfy population sensitivity and policy sensitivity (see Annex 1.4). Now consider a regression of aid on income per capita and population, similar to that estimated by Easterly (2007). The estimated slope coefficient for income per capita again satisfies income sensitivity but not policy sensitivity (Annex 1.4). Perhaps more surprisingly, this coefficient also does not satisfy population sensitivity, despite the fact that population is included in the regression as an explanatory variable. The reason is that the response of the slope coefficient for income per capita (from a regression which controls for population) to a reallocation between countries with different levels of population depends on the covariance between income per capita and population. This covariance could in turn be either positive or negative, depending on prevailing levels of the two variables among aid recipients. There can therefore be no guarantee that a reallocation to a larger recipient will always lower (i.e. improve) the slope coefficient for income per capita, and so population sensitivity is not satisfied in the strong sense referred to above.

Now consider a regression of aid on income per capita, population and a measure of policy, similar to that estimated by Knack et al (2011). . The slope coefficient for income per capita again satisfies income sensitivity but neither population nor policy sensitivity, at least in the strong sense referred to above (it does however satisfy policy sensitivity in the weak sense). Thus in none of these three cases – a simple bivariate regression of aid on income per capita, or a multiple regression of aid on income per capita and population, or income per capita, population and policy – can we say that the slope coefficient for income per capita provides a good performance measure according to our criteria. The same applies for any other slope coefficients estimated in this way. For example, while the coefficient for policy from a regression of aid on income per capita, population and policy satisfies policy sensitivity, it fails to satisfy income or population sensitivity, at least in the strong sense referred to above.

The next question is therefore whether some combination of regression coefficients meets our criteria. Consider, for example, the (unweighted) average of the slope

coefficients on policy and income per capita from a regression of aid on these variables and population, similar to the measure calculated by Knack *et al.* (2011). We find that this measure also fails to meet our criteria, at least in the strong sense (it does meet all three in the weak sense). On balance therefore, existing performance measures based on regression coefficients do not meet our criteria for a good performance measure - even when running multiple regressions including population and policy as well as income per capita as explanatory variables.

### 3.5 Performance indices

In contrast to the other measures, performance indices have been designed specifically for assessing allocative performance (McGillivray 2004). Most take the general form:

$$I = \frac{1}{A} \sum_i w_i A_i \quad (3)$$

where  $w_i$  is a weight reflecting some characteristic(s) of recipient  $i$ ,  $A_i$  is aid given to recipient  $i$ , and  $A$  is the donor's total aid. Usually, the weights are constrained to lie between 0 and 1 (or 0 and 100), so the performance index will also lie between 0 and 1 (or 0 and 100), with higher values indicating better performance. Negative aid values can cause problems for indices of this sort, and are therefore often excluded when calculating the index (e.g. by focusing on gross aid disbursements). An alternative to equation (3) which has sometimes been used (e.g. McGillivray 1989) is:

$$I' = \frac{1}{\sum_i a_i} \sum_i w_i a_i \quad (4)$$

where  $a_i$  is aid per capita.

A key issue with performance indices is how the weights  $w_i$  are calculated. Three different formulae have been proposed in the literature to date, namely:

$$w_i = \frac{y_{\max} - y_i}{y_{\max} - y_{\min}} \quad (5)$$

$$w_i = \frac{N_i/y_i - (N/y)_{\min}}{(N/y)_{\max} - (N/y)_{\min}} \quad (6)$$

$$w_i = \frac{G_i - G_{\min}}{G_{\max} - G_{\min}} \cdot \frac{y_{\max} - y_i}{y_{\max} - y_{\min}} \quad (7)$$

where  $N$  is population,  $y$  is per capita income, and  $G$  is a measure of policy. The first two formulae were proposed by McGillivray (1989, 1992), while the third was proposed by Roodman (2006). In their review, White and McGillivray (1995) refer to the combination of equation (4) and (5) as the 'McGillivray performance index'

(MPI), and the combination of (3) and (6) as the ‘adjusted McGillivray performance index’ (API). We follow this terminology here; we also refer to the combination of (3) and (5) as the ‘income performance index’ (IPI) and the combination of (3) and (7) as the ‘Roodman performance index’ (RPI).<sup>18</sup> More recently, Birdsall and Kharas (2010) calculate two performance indices based on equation (5), one to measure the ‘poverty orientation’ of aid allocations and the other to measure ‘good governance’ orientation. The weights used to calculate these indices are simply given by the levels of (log) GDP per capita and the Kaufmann et al (2009) composite governance indicator for each recipient.<sup>19</sup>

How do these indices perform when judged against the criteria developed in Section 2? While the IPI, API, MPI and RPI all satisfy income sensitivity, none satisfies all three criteria. The RPI satisfies income and policy sensitivity, but not population sensitivity, while the API satisfies income and population sensitivity but not policy sensitivity. None of these indices can therefore be considered a good measure of allocative performance if we believe that aid should be allocated according to policy as well as need. However, the API can at least be considered a good measure if we believe that aid should be allocated according to country need alone, since it satisfies income and population sensitivity (the only existing index to do so).

Our findings with regard to the MPI and API are worth comparing with those of White and McGillivray (1995). These authors argue that the advantage of the API over the MPI is that while a regressive reallocation can improve the latter – not considered desirable – it cannot improve the former.<sup>20</sup> However, a regressive reallocation can improve both the API and the MPI, as shown by the example in Table 2. Our results point to a different advantage of the API: it satisfies population sensitivity, while the MPI does not.

The formulae in equations (5) to (7) implicitly assume that aid has no impact on per capita income. Rao (1994, 1997) proposes an alternative performance index which assumes that aid translates one-to-one into income. Although defined differently to

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<sup>18</sup> Note that the RPI as defined here is only one component – the ‘selectivity’ component – of the overall index of donor performance calculated by Roodman (2006). It is also worth noting that Roodman himself views the RPI (as defined here) not so much as an index but as the ratio of a donor’s ‘selectivity weighted aid’ to its actual aid; his interest is more in the numerator of this ratio rather than the ratio itself.

<sup>19</sup> See in particular Birdsall and Kharas (2010: 44-45). These authors use a slightly different measure of aid – strict country programmable aid – when calculating good governance orientation.

<sup>20</sup> See in particular White and McGillivray (1995: 176, Table 4) and associated discussion. These authors do however state elsewhere that the advantage of the API is that it “combines aid share and aid population considerations in a single measure, thus avoiding the problem of small-country bias.” (ibid: 176). This argument matches more closely with the advantage of the API in terms of our criteria, i.e. it satisfies both income and population sensitivity.

the four indices discussed above, this index has the same property as the IPI, namely a progressive (regressive) reallocation always improves (worsens) performance (see Rao 1994: 1582). Like the IPI therefore, this index satisfies income sensitivity but fails to satisfy population and policy sensitivity.

### 3.6 Summary

A summary of the results in this section is shown in Table 3. As this makes clear, no existing allocative performance measure meets all three of the criteria set out in Section 2. Since these criteria are designed to be of wide appeal, making only minor assumptions regarding the features of an ideal aid allocation, this provides grounds for rejecting all existing measures which have been used in the literature to date. The only exception is the API, which is the only measure to satisfy income and population sensitivity. This could be considered a good measure, but only if we believe that aid should be allocated according to country need alone – and not if we believe that aid should be allocated according to policy as well as need. Since many people do now take the latter position, we propose in Section 4 a new measure which does meet all three of our criteria.

## 4 A new measure

In this section, we propose a new measure which meets all three of the criteria proposed in Section 2, namely income, population and policy sensitivity. This measure, which we refer to as the Generalised Performance Index (GPI), is given by:

$$GPI = \frac{1}{A} \sum \left[ \lambda_1 \left( \frac{N_i - N_{\min}}{N_{\max} - N_{\min}} \right) + \lambda_2 \left( \frac{G_i - G_{\min}}{G_{\max} - G_{\min}} \right) + \lambda_3 \left( \frac{y_{\max} - y_i}{y_{\max} - y_{\min}} \right) \right] \cdot A_i \quad (8)$$

where  $\lambda_1, \lambda_2$  and  $\lambda_3$  are weights attached to the three components of the index (population, policy and income per capita), with  $\lambda_1 + \lambda_2 + \lambda_3 = 1$ . These weights are to be determined by the person (or institution) doing the assessment. In this paper we have identified two different positions, namely:

- 1) aid should be allocated according to country need alone; this implies setting  $\lambda_1, \lambda_3 > 0$  and  $\lambda_2 = 0$ ;
- 2) aid should be allocated according to country policy as well as need, which implies setting  $\lambda_1, \lambda_2, \lambda_3 > 0$ .

Clearly, these two positions are very broad and the more pressing question is how more specific values of the  $\lambda$  terms might be set. The 'default' position is equal weighting, i.e.  $\lambda_1 = \lambda_3 = 0.5$  (position 1) or  $\lambda_1 = \lambda_2 = \lambda_3 = 0.33$  (position 2), although this is more because of the lack of a viable alternative than any inherent merit. The flexible weighting system in the formula for the GPI is preferable to a fixed

weighting system which forces (often implicitly) a particular weighting system on the evaluator. Moreover, the same problem of deciding weightings applies equally to other well-known indices, such as the Human Development Index.

Three other points are worth noting. First, the GPI is similar to the RPI (see Section 3.5), but departs from it by including a separate population component. Second it uses the arithmetic rather than the geometric average of each component. We also calculated a geometric version of the GPI, but found that it generates very similar rankings of donors to the additive version shown by equation (8) (details available on request).<sup>21</sup> Third, it makes sense when calculating the GPI to measure income and population in log units, since both variables are positively skewed, but not policy since this variable typically has a more normal distribution.

With  $\lambda_1, \lambda_2, \lambda_3 > 0$ , the GPI meets all three criteria set out in Section 2 (see Annex 1.6). We do not claim that the GPI is the only possible measure that meets these criteria, nor that it meets all possible criteria for a good performance measure. It does meet some of the other desirable criteria discussed by White and McGillivray (1995), namely scale neutrality and no anti-concentration bias, but it fails the criterion that a performance measure should not be maximised by giving all aid to a single recipient (i.e. complete specialisation).<sup>22</sup> However, very few measures have been shown to meet this particular criterion; White and McGillivray (1995) identified only one – the correlation coefficient – and this measure fails to meet various other our criteria (including our own). Therefore, the GPI does represent an improvement over existing performance measures: it is the only measure to meet all three criteria set out in Section 2, as well as a number of other desirable criteria.

The more practical question is whether the GPI generates different rankings of donor allocative performance, in comparison with existing measures. If it gives very similar results, failure of existing measures to satisfy our criteria may not be considered a pressing concern. To investigate this possibility, Table 4 reports donor rankings based on the GPI and the various measures discussed in Section 3 but using the same

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<sup>21</sup> The key conceptual difference is that under the geometric version, donors are penalised more severely for aiding recipients with low scores for one particular component (e.g. small population, poor governance, or high income per capita). The additive version also satisfies our criteria without any exceptions, unlike the geometric version.

<sup>22</sup> The GPI meets the criterion of scale neutrality, since if we multiply all aid values (including total aid) by a constant parameter, the measure is unaltered. It meets the criterion of anti-concentration bias since it does not require some aid to be given to all recipients in order to reach its maximum value. The GPI can however be maximised by giving all aid to a single recipient – namely that recipient with the highest weighted average of the three terms of the GPI – at least if we assume that aid has no impact on per capita income (if aid does have an impact on per capita income, we can no longer be sure that the GPI would be maximised by such an allocation).

data (the one exception to this is Easterly and Williamson (2011) who use a proprietary dataset, and so their final rankings are used here rather than their method); the actual values of each measure are shown in Table 5. We also show in Table 6 the Spearman rank correlation coefficients between these measures, to assist interpretation. Ranking is commonplace within the aid allocation literature, indeed it is the major technique used to present measures of allocative performance, and thus it is appropriate to see whether the measures agree in this way. We carry out this analysis for the 23 bilateral donors of the OECD-DAC using data for 2009, with equal weighting factors ( $\lambda_1 = \lambda_2 = \lambda_3 = 1/3$ ) and with income and population (but not policy) measured in log units.

The main point to note from Tables 4-6 is that the GPI often generates quite different rankings to existing measures. Table 4 shows that New Zealand is one of the worst donors according to the GPI, but it tops the MPI rankings and is second in the Suits index. Sweden and Switzerland are praised by EW but chastised by the GPI. Greece and Korea perform well according to the GPI and poorly in the KRE rankings, the opposite of the USA and UK. Looking more generally at the coefficients in Table 6, we see that the highest (positive) correlation for the GPI is with the RPI (0.8), which is not surprising given the similarities between these indices. There is also a moderate positive correlation (0.4) with the API. But the remaining correlations with competing and popular measures – the Easterly and Williamson (2011) headcount measure, Knack et al (2011) regression coefficient measure, the Suits index, and the MPI – are typically low or even negative. Thus the failure of existing performance measures to satisfy our criteria does appear to be of practical significance. Table 6 also confirms the point made in the introduction, namely that existing measures of donor allocative performance often generate quite different rankings. For example, the rank correlation between the API and MPI is -0.24, while that between the measures used by Knack et al (2011) and Easterly and Williamson (2011) is -0.03.

## 5 Conclusion

This paper reviews the various measures which have been used in the recent literature to assess how well donors allocate their aid across countries. We begin in Section 2 by proposing three desirable criteria for a measure of allocative performance, which make only limited assumptions about the features of an ideal aid allocation. We then show in Section 3 that none of the existing measures used in the literature meet all three of these criteria. In Section 4 we therefore propose a new measure, the generalised performance index (GPI), that does meet our criteria. We present rankings of the allocative performance of the 23 OECD-DAC bilateral donors (in 2009) on the basis of this measure, and show that the ranking differs quite substantially from those based on existing measures.

Our paper builds on an earlier review carried out by White and McGillivray (1995), but takes a different approach and comes to different conclusions. These authors take the position that aid should be allocated according to country 'need' alone, and assess performance measures on this basis. We take a broader approach, and also consider what constitutes a good measure if we believe that aid should be allocated according to country policy as well as need. We also show that one of the criteria proposed by White and McGillivray (1995) – that regressive reallocations must not improve allocative performance – is based on rather restrictive assumptions about the determinant's of a country's need for aid. Our criteria, by contrast, are based on much less restrictive assumptions.

We do not claim that our criteria are the only desirable criteria for a measure of allocative performance. Further work in terms of identifying and examining additional criteria is therefore needed. Nevertheless, the criteria we propose are of broad appeal, and that no pre-existing measure of performance meets them is clearly of concern. Measures of donor performance are increasingly common in the literature, beginning with Roodman (2006) and including more recently Easterly and Pfutze (2008), Knack et al (2011), Birdsall and Kharas (2010), and Easterly and Williamson (2011). Although these studies aim to assess donors' overall performance, they each contain an assessment of allocative performance. If measures of allocative performance rest on weak foundations, one may question the validity of overall performance measures, and the rankings of donors they generate.

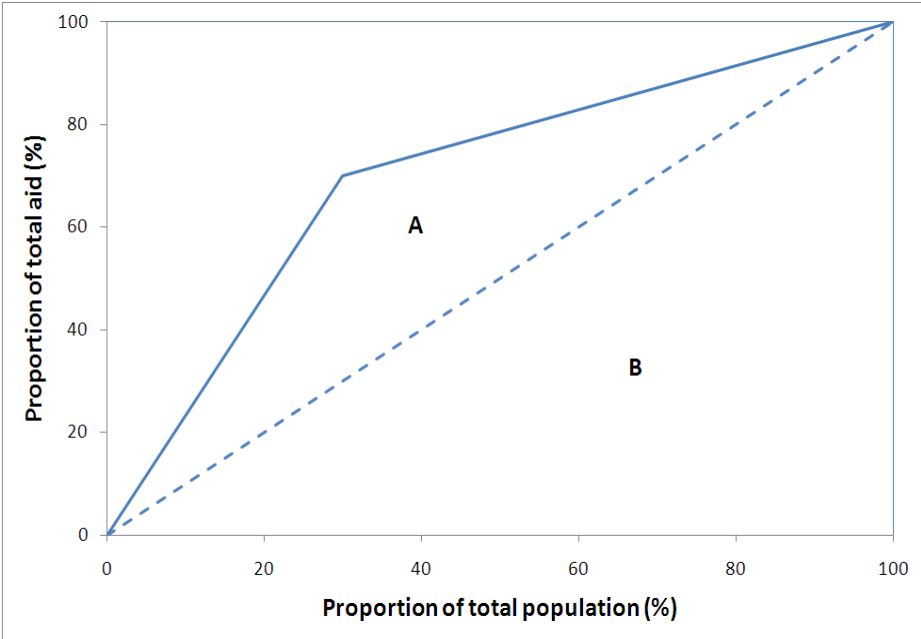
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Figure 1. The aid concentration curve.



**Table 1. Country specialisation: a hypothetical example**

	Recipient X	Recipient Y	Totals
Donor A	30	45	75
Donor B	70	5	75
Totals	100	50	150

Notes: The figures in this example refer to levels of aid in value (e.g. \$) terms. Recipient X is assumed to have lower income per capita than country Y, but identical in other respects.

**Table 2. Regressive reallocations: the API vs. the MPI**

	y (US\$, PPP)	N (m)	Aid (\$m)	Reallocation 1	Reallocation 2
Bangladesh	1,286	162	2,598	2,498	2,598
Cambodia	1,739	15	898	998	798
Pakistan	2,369	170	5,434	5,434	5,534
API (*100)			12.286	12.256	12.302
MPI (*100)			10.253	10.254	10.255

Notes: Reallocation 1 transfers \$100 million from Bangladesh to Cambodia; this improves the MPI but worsens the API. Reallocation 2 transfers \$100 million from Cambodia to Pakistan; this improves both the MPI and the API. The API and MPI are calculated on the basis of data for 2009 for 117 recipient countries (aid to all other recipients is assumed fixed) and include aid from all donors.

**Table 3. Properties of existing allocative performance measures**

	H	S	r	b <sub>y</sub> (b)	b <sub>y</sub> (m)	b <sub>G</sub> (m)	b (y,G)	IPI	API	RPI	MPI
Income sensitivity	No	Yes	Yes	Yes	Yes	No*	No*	Yes	Yes	Yes	Yes
Population sensitivity	No	No	No	No	No	No*	No*	No	Yes	No	No
Policy sensitivity	No	No	No	No	No	Yes	No*	No	No	Yes	No

Notes: H=headcount measure (with income per capita as the grouping variable); S= Suits index (income per capita as the ranking variable); r=correlation coefficient (between aid and per capita income), b<sub>y</sub> (b) = slope coefficient for per capita income in a bivariate regression of aid on per capita income; b<sub>y</sub> (m) = slope coefficient for per capita income in a multiple regression of aid on per capita income and population; b<sub>G</sub> (m) = slope coefficient for policy in a multiple regression of aid on per capita income, population and policy; b(y,G) = weighted average of slope coefficients for income per capita and policy in a multiple regression of aid on per capita income, population and policy; IPI, API, RPI and MPI: see Section 3.5; \* indicates a failure to satisfy a criterion in the strong sense, but not in the weak sense (see Section 3.4).

**Table 4. Rankings of donor allocative performance by measure, 2009**

Donor	GPI	r	S	API	MPI	RPI	KRE	EW
Australia	16	5	9	13	8	18	22	16
Austria	6	19	5	8	4	6	15	1
Belgium	23	3	8	19	5	22	4	10
Canada	14	12	22	12	16	21	9	13
Denmark	12	1	11	15	13	12	12	17
Finland	15	5	23	7	7	14	16	15
France	9	21	7	9	23	8	17	7
Germany	3	16	5	2	9	4	2	12
Greece	4	23	1	22	19	1	19	2
Ireland	17	5	21	4	3	19	4	14
Italy	11	15	13	17	12	13	19	3
Japan	2	10	10	3	20	7	6	18
Korea	1	20	16	6	17	2	11	.
Luxembourg	7	17	11	20	15	2	14	22
Netherlands	19	1	17	11	22	16	12	11
New Zealand	22	22	2	21	1	23	21	21
Norway	10	10	14	5	18	9	6	9
Portugal	21	18	3	23	2	11	23	20
Spain	5	13	4	18	9	5	8	8
Sweden	20	13	18	14	14	17	10	5
Switzerland	18	9	20	16	6	10	17	6
UK	13	4	19	1	11	20	3	19
USA	8	8	15	10	21	15	1	4

Notes: The GPI is calculated according to equation (10), with income and population measured in log units and equal weighting factors; r=Spearman rank correlation coefficient between aid per capita and income per capita; S= Suits index (income per capita as the ranking variable); for definitions of API, MPI and RPI see Section 3.5; KRE = selectivity score calculated by Knack et al. (2011); EW is the selectivity rank based on headcount measures calculated by Easterly and Williamson (2011). All measures are scaled so that positive scores reflect good performance. All calculations are authors' own, except for EW for which the corruption data used are not publicly available. Thus the final rankings on the selectivity score are taken from Easterly and Williamson (2011), and applied to the 22 donors that are included in both samples (South Korea is not included in their sample). Aid data refer to 2009, but all other variables are lagged by one year, and so refer to 2007. A star denotes significance at the 5% level.

**Table 5 Measures of donor allocative performance, 2009**

Donor	GPI	r	S	API	MPI	RPI	KRE	EW
Australia	42.23	0.35	-0.15	6.42	81.36	14.34	-0.14	16
Austria	48.16	0.08	-0.03	7.88	83.12	23.03	0.15	1
Belgium	31.26	0.40	-0.14	4.70	82.60	12.25	0.27	10
Canada	43.01	0.24	-0.51	6.51	73.62	13.42	0.23	13
Denmark	44.03	0.41	-0.23	6.20	76.04	17.90	0.18	17
Finland	42.64	0.35	-0.55	8.05	81.47	16.07	0.14	15
France	45.52	0.03	-0.04	7.23	16.46	20.05	0.08	7
Germany	54.23	0.16	-0.03	20.32	79.40	23.52	0.32	12
Greece	51.04	-0.26	0.27	2.87	70.14	30.05	0.01	2
Ireland	42.08	0.35	-0.47	8.46	84.83	14.03	0.27	14
Italy	44.40	0.17	-0.24	5.99	78.59	16.45	0.01	3
Japan	55.22	0.27	-0.16	19.61	51.89	22.45	0.26	18
Korea	56.36	0.05	-0.33	8.26	73.50	25.24	0.19	.
Luxembourg	47.10	0.15	-0.23	4.67	75.55	25.24	0.17	22
Netherlands	39.45	0.41	-0.34	6.55	24.25	15.60	0.18	11
NewZealand	31.64	-0.02	0.08	3.31	86.68	11.44	-0.12	21
Norway	45.36	0.27	-0.25	8.27	70.57	19.42	0.26	9
Portugal	34.27	0.09	0.04	2.28	86.56	18.70	-0.16	20
Spain	49.31	0.21	-0.01	5.23	79.40	23.34	0.24	8
Sweden	37.38	0.21	-0.37	6.40	75.61	15.36	0.20	5
Switzerland	41.95	0.29	-0.40	6.15	81.81	18.96	0.08	6
UK	43.27	0.39	-0.39	21.65	79.13	14.02	0.31	19
USA	45.69	0.30	-0.30	6.72	33.11	16.02	0.33	4

Notes: See Table 4.

**Table 6. Rank correlations between measures of donor allocative performance, 2009**

	GPI	r	S	API	MPI	RPI	KRE	EW
GPI	1							
R	-0.38	1						
S	0.22	-0.58*	1					
API	0.37	0.29	-0.46*	1				
MPI	-0.49*	0.02	0.14	-0.24	1			
RPI	0.80*	-0.52*	0.38	0.02	-0.33	1		
KRE	0.25	0.42*	-0.34	0.61*	-0.22	-0.10	1	
EW	-0.24	0.21	-0.02	0.00	0.25	-0.26	-0.03	1

Notes: As Table 4.

## Annex 1

In this annex we aim to show more formally whether the allocative performance measures considered in Section 3 meet the three desirable criteria defined in Section 2.2, namely income, population and policy sensitivity. The following notation is used:  $A_i$  = aid in value terms;  $A = \sum A_i$  = total aid from a donor in value terms;  $\hat{a}_i = A_i/N_i$  = aid per capita;  $\hat{a} = \sum \hat{a}_i$ ;  $y_i$  = income per capita;  $N_i$  = population;  $G_i$  = a governance (or policy) indicator;  $x_{max}$  = maximum level of variable  $x$ ;  $x_{min}$  = minimum level of variable  $x$ ;  $x_r = x_{max} - x_{min}$  = range of variable  $x$ . The subscript  $i$  indicates a recipient country; subscripts for donors are omitted for reasons of clarity. All summation signs refer to recipients ( $i$  or  $j=1, \dots, N$ ), unless otherwise stated.  $N$  is the number of recipient countries.

To determine whether our criteria are met, we first consider the response of the performance measure to a reallocation of aid from one recipient  $n$  to another recipient  $m$  with aid to all other recipients held constant, i.e.  $dA_m = -dA_n > 0$ ,  $dA_{i \neq m, n} = 0$ , and where the two recipients have the same initial amount of aid (i.e.  $A_m = A_n$ ). We then examine the properties of this response (e.g. whether it is always positive, or always negative) in cases where the reallocation is regressive ( $y_m > y_n$ ), progressive ( $y_m < y_n$ ), from a smaller to a larger country ( $N_m > N_n$ ), and so on. We assume throughout that  $dy_i/dA_i = 0$ .

The annex is organised as follows:

- A1.1 The headcount
- A1.2 The Suits index
- A1.3 The correlation coefficient
- A1.4 Regression coefficients
- A1.5 Performance indices
- A1.6 A new measure

### A1.1 The headcount

The headcount measure of allocative performance is given by:

$$H = \frac{1}{A} \sum_{i=1}^K A_i \quad (\text{A1.1})$$

where  $K$  is the number of recipients in a specified group (e.g. low income countries, countries with poor governance, and so on). Clearly, if two recipients  $n$  and  $m$  belong to the same group, then a reallocation from  $n$  to  $m$  has no impact on the headcount measure, irrespective of whether the reallocation is progressive or regressive, to a recipient with a larger or smaller population, or to a recipient with better or worse policy. Thus none of the three criteria are met.

### A1.2 The Suits index

The approximate formula for the Suits index is given by:

$$S = 1 - \sum p_j (CA_j + CA_{j-1}) \quad (\text{A2.1})$$

where  $p_j = \frac{N_j}{\sum N_j}$  and  $CA_j = \sum_{i=1}^j \frac{A_i}{A}$ . Equation (A2.1) can be re-written as:

$$S = 1 - \frac{1}{A} \sum p_j \left( A_{i=j} + 2 \sum_{i=1}^{j-1} A_i \right) \quad (\text{A2.2})$$

The differential of equation (A2.2) is given by:

$$dS = \sum_i \left[ \frac{1}{A} \sum_j p_j \left( A_{i=j} + 2 \sum_i^{j-1} A_i \right) - \left( p_i + 2 \sum_{j=i+1} p_j \right) \right] \frac{dA_i}{A} \quad (\text{A2.3})$$

The response of the Suits index to a marginal reallocation of aid from recipient  $n$  to recipient  $m$  is therefore:

$$dS = \left[ (p_n - p_m) + 2 \left( \sum_{j=n+1} p_j - \sum_{k=m+1} p_j \right) \right] \frac{dA_m}{A} \quad (\text{A2.4})$$

Consider the case where the ranking variable is income per capita. This means that for a regressive reallocation we have  $m > n$ , and so equation (A2.4) can be simplified to:

$$dS = \left[ p_m + p_n + 2 \sum_{k=n+1}^{m-1} p_k \right] \frac{dA_m}{A} \quad (\text{A2.5})$$

Similarly, for a progressive reallocation we have  $m < n$ . This means that equation (A2.4) can be simplified to:

$$dS = - \left[ p_m + p_n + 2 \sum_{k=m+1}^{n-1} p_k \right] \frac{dA_m}{A} \quad (\text{A2.6})$$

Equation (A2.5) will always be positive, while equation (A2.6) will always be negative. This means that a regressive (progressive) reallocation will always increase (reduce) the Suits index, i.e. worsen (improve) performance, if income per capita is the ranking variable. In this case therefore, income sensitivity is met. If two recipients have the same income per capita, then their ranking is indeterminate. This means that the effect of a reallocation from a larger to a smaller country, or from a country with better policy to one with worse policy, is also indeterminate, since either equation A2.5 or A2.6 could apply.



### A1.3 The correlation coefficient

The correlation coefficient between two variables  $X_1$  and  $X_2$  is given by:

$$r = \frac{\sum (X_{1i} - \bar{X}_1)(X_{2i} - \bar{X}_2)}{\sqrt{\sum (X_{1i} - \bar{X}_1)^2} \sqrt{\sum (X_{2i} - \bar{X}_2)^2}} \quad (\text{A3.1})$$

Consider first the correlation between income per capita and aid as a share of a donor's total, i.e.  $X_1 = y_i$ ,  $X_2 = A_i/A$ . Equation (A3.1) can be rewritten as:

$$r = \frac{\sum (y_i - \bar{y})A_i}{\sqrt{\sum (y_i - \bar{y})^2} \sqrt{\sum A_i^2 - A^2/N}} = \frac{\delta}{(\alpha\phi)^{0.5}} \quad (\text{A3.2})$$

where  $\delta = \sum (y_i - \bar{y})A_i$ ,  $\alpha = \sum (y_i - \bar{y})^2$  and  $\phi = \sum A_i^2 - A^2/N$ . The differential version of equation (A3.2) is given by:

$$dr = \frac{1}{(\alpha\phi)^{0.5}} \sum \left[ (y_i - \bar{y}) - \frac{\delta(A_i - \bar{A})}{\phi} \right] \cdot dA_i \quad (\text{A3.3})$$

The response of the correlation coefficient to a marginal reallocation of aid from  $n$  to  $m$ , with aid to all other recipients held constant, is therefore:

$$dr = \frac{1}{(\alpha\phi)^{0.5}} \left[ (y_m - y_n) - \frac{\delta(A_m - A_n)}{\phi} \right] \cdot dA_m \quad (\text{A3.4})$$

If  $A_m = A_n$ , the effect of a reallocation is:

$$dr = \frac{y_m - y_n}{(\alpha\phi)^{0.5}} dA_m \quad (\text{A3.5})$$

In this case, a progressive (regressive) reallocation always lowers (raises) the value of  $r$ , i.e. improves (worsens) performance. Thus income sensitivity is met. Population and policy sensitivity are not met because if  $A_m = A_n$  and  $y_m = y_n$ , a reallocation has no impact on the coefficient. The same results apply if aid is measured in log terms. If aid is measured in per capita terms, the correlation coefficient with income per capita is given by:

$$r = \frac{\sum (y_i - \bar{y})\hat{a}_i}{\sqrt{\sum (y_i - \bar{y})^2} \sqrt{\sum \hat{a}_i^2 - \hat{a}^2/N}} = \frac{\chi}{(\alpha\beta)^{0.5}} \quad (\text{A3.6})$$

The differential version of equation (A3.6) is given by:

$$dr = \frac{1}{(\alpha\beta)^{0.5}} \sum \frac{1}{N_i} \left[ (y_i - \bar{y}) - \frac{\chi(\hat{a}_i - \bar{\hat{a}})}{\beta} \right] \cdot dA_i \quad (\text{A3.7})$$

The response of the correlation coefficient to a marginal reallocation from  $n$  to  $m$  is therefore:

$$dr = \frac{1}{(\alpha\beta)^{0.5}} \left[ \left( \frac{y_m}{N_m} - \frac{y_n}{N_n} \right) - \frac{\chi}{\beta} \left( \frac{A_m}{N_m^2} - \frac{A_n}{N_n^2} \right) + \left( \frac{\bar{a}\chi}{\beta} - \bar{y} \right) \left( \frac{1}{N_m} - \frac{1}{N_n} \right) \right] \cdot dA_m \quad (\text{A3.8})$$

If  $A_m = A_n$  and  $N_m = N_n$ , the effect of a reallocation is given by:

$$dr = \frac{y_m - y_n}{(\alpha\beta)^{0.5} N_m} dA_m \quad (\text{A3.9})$$

In this case, a progressive (regressive) reallocation always lowers (raises) the value of  $r$ , i.e. improves (worsens) performance. Thus income sensitivity is met. If also  $y_m - y_n$ , then a reallocation has no impact on the coefficient, and so policy sensitivity is not met. If  $A_m = A_n$  and  $y_m - y_n$  but  $N_m \neq N_n$ , the effect of a reallocation is given by:

$$dr = \frac{1}{(\alpha\beta)^{0.5}} \left\{ \left( \frac{\bar{a}\chi}{\beta} + y_m - \bar{y} \right) \left( \frac{1}{N_m} - \frac{1}{N_n} \right) + \frac{A_m \chi}{\beta} \left( \frac{1}{N_n^2} - \frac{1}{N_m^2} \right) \right\} dA_m \quad (\text{A3.10})$$

In this case, a reallocation to a larger (smaller) country does not always lower (raise) the value of  $r$ . Thus population sensitivity is not met.

### A1.4 Regression coefficients

Consider a regression of the form:

$$a_i = b_1 + b_2 X_{2i} + \dots + b_K X_{Ki} + u_i \quad (\text{A4.1})$$

where  $a_i$  is some aid variable (e.g. the aid share, or the log of aid) and  $X_2, \dots, X_K$  is a set of explanatory variables with  $K \geq 2$ . Equation (A4.1) can be written in matrix form as:

$$\mathbf{a} = \mathbf{X}\mathbf{b} + \mathbf{u} \quad (\text{A4.2})$$

where  $\mathbf{a}$  and  $\mathbf{u}$  are (1xN) row vectors,  $\mathbf{b}$  is a (Kx1) column vector, and  $\mathbf{X}$  is a (NxK) matrix. The formula for the estimated regression coefficients is:

$$\mathbf{b} = (\mathbf{X}'\mathbf{X})^{-1} \mathbf{X}'\mathbf{a} = \mathbf{W}\mathbf{a} \quad (\text{A4.3})$$

where  $\mathbf{W}$  is a (KxN) matrix. Thus we can also write:

$$b_k = \sum w_{ki} a_i \quad (\text{A4.4})$$

where  $w_{ki}$  is the element  $(k,i)$  from matrix  $\mathbf{W}$ . It helps if we also define a (KxK) matrix  $\mathbf{Z}$ :

$$\mathbf{Z} = (\mathbf{X}'\mathbf{X})^{-1} \quad (\text{A4.5})$$

This means that:

$$w_{ki} = z_{k1} + z_{k2} X_{2i} + \dots + z_{kK} X_{Ki} = \sum_{j=1}^K z_{kj} X_{ji} \quad (\text{A4.6})$$

where  $z_{kj}$  is element  $(k,j)$  from the matrix  $\mathbf{Z}$ . Note that  $\mathbf{Z}$  is a positive definite matrix, and so all diagonal terms are positive; it is also symmetric, so that  $z_{kj} = z_{jk}$ . The values of  $z_{kj}$  depend on the levels of the explanatory variables among aid recipients. Values based on current (2009) data are shown in Table A1.

Consider first the case where aid is measured in log terms, i.e.  $a_i = \ln A_i$ . The differential version of equation (A4.4) is given by:

$$db_k = \sum \frac{w_{ki}}{A_i} dA_i \quad (\text{A4.7})$$

If  $A_m = A_n$ , the effect of a reallocation from  $m$  to  $n$  is given by:

$$db_k = \sum_{j=1}^K z_{kj} (X_{jm} - X_{jn}) \frac{dA_m}{A_m} \quad (\text{A4.8})$$

Now consider a simple bivariate regression (K=2) of the log of aid on income per capita ( $X_2$ ). The effect of the reallocation on the slope coefficient is given by:

$$db_2 = z_{22}(X_{2m} - X_{2n}) \frac{dA_m}{A_m} \quad (\text{A4.9})$$

Since  $\mathbf{Z}$  is a positive definite matrix, the term  $z_{22}$  is always positive. Thus a progressive (regressive) reallocation will always lower (raise) the value of the slope coefficient from this regression, i.e. improve (worsen) performance. This measure therefore satisfies income sensitivity. It does not satisfy population or policy sensitivity because if two recipients have the same income per capita, a reallocation has no impact on the measure.

Now consider a multiple regression (K=3) of aid on income per capita ( $X_2$ ) and population ( $X_3$ ). The effect of the reallocation on the slope coefficient for income per capita is now given by:

$$db_2 = [z_{22}(X_{2m} - X_{2n}) + z_{23}(X_{3m} - X_{3n})] \frac{dA_m}{A_m} \quad (\text{A4.10})$$

Income sensitivity is again satisfied but policy sensitivity is not. Since the parameter  $z_{23}$  is not a diagonal element of  $\mathbf{Z}$  its value could be positive or negative. Thus population sensitivity is not met in the strong sense. The value of  $z_{23}$  based on current data is in fact positive (Table A1), and so population sensitivity is not met in the weak sense either.

Now consider a multiple regression (K=4) of aid on income per capita ( $X_2$ ), population ( $X_3$ ) and policy ( $X_4$ ). The effect of the reallocation on the slope coefficient for income per capita is now given by:

$$db_2 = [z_{22}(X_{2m} - X_{2n}) + z_{23}(X_{3m} - X_{3n}) + z_{24}(X_{4m} - X_{4n})] \frac{dA_m}{A_m} \quad (\text{A4.11})$$

Again, income sensitivity is satisfied but population sensitivity is not, in either the strong or weak sense. Policy sensitivity is not satisfied in the strong sense, since  $z_{24}$  could be either positive or negative, but it is satisfied in the weak sense, since the current value of  $z_{24}$  is negative. The effect of the reallocation on the slope coefficient for policy is given by:

$$db_4 = [z_{42}(X_{2m} - X_{2n}) + z_{43}(X_{3m} - X_{3n}) + z_{44}(X_{4m} - X_{4n})] \frac{dA_m}{A_m} \quad (\text{A4.12})$$

Policy sensitivity is satisfied because  $z_{44}$  is positive. Income sensitivity is not satisfied in the strong sense ( $z_{42}$  could be positive or negative), but it is satisfied in the weak sense (the current value of  $z_{42}$  is negative). Similarly, population sensitivity is not

satisfied in the strong sense ( $z_{43}$  could be positive or negative), but it is satisfied in the weak sense (the current value of  $z_{43}$  is positive).

Finally, consider the average of the slope coefficients for income per capita and policy from a multiple regression ( $K=4$ ) of aid on income per capita, population and policy. This is given by:

$$\bar{b}_{2,4} = \sum [\lambda w_{4i} - (1-\lambda)w_{2i}] \cdot a_i \quad (\text{A4.13})$$

The effect of a reallocation of aid from  $n$  to  $m$ , assuming equal initial levels of aid, is given by:

$$d\bar{b}_{2,4} = [\chi(X_{2n} - X_{2m}) + \delta(X_{3m} - X_{3n}) + \varepsilon(X_{4m} - X_{4n})] \frac{dA_m}{A_m} \quad (\text{A4.14})$$

where  $\chi = (1-\lambda)z_{22} - \lambda z_{42}$ ,  $\delta = \lambda z_{43} - (1-\lambda)z_{23}$  and  $\varepsilon = \lambda z_{44} - (1-\lambda)z_{24}$ . The parameters  $\chi$ ,  $\delta$  and  $\varepsilon$  could be positive or negative, so income, population and policy sensitivity are not met in the strong sense. However, income and policy sensitivity are met in the weak sense (the current value of  $z_{42}$  is negative), and population sensitivity is met in the weak sense if:

$$\frac{\lambda}{1-\lambda} > \frac{z_{23}}{z_{43}} (= 0.15) \quad (\text{A4.15})$$

The results in this section apply equally if aid is measured as a share of a donor's total aid; all that differs is that the term  $dA_m/A_m$  in equations (A4.8) to (A4.12) and (A4.14) is replaced by  $dA_m/A$ .

**Table A1 Z values, 2009 data**K=3 ( $X_2$ =income per capita,  $X_3$ =population)

	1	2	3
1	1.177962	-0.06769	-0.03839
2	-0.06769	0.006916	0.000639
3	-0.03839	0.000639	0.002093

K=4 ( $X_2$ =income per capita,  $X_3$ =population,  $X_4$ =policy)

	1	2	3	4
1	1.204517	-0.073221	-0.036599	0.027058
2	-0.073221	0.008070	0.000266	-0.005639
3	-0.036599	0.000266	0.002214	0.001823
4	0.027058	-0.005639	0.001823	0.027569

Notes: Income per capita and population are both measured in log terms, but policy is not. The policy indicator used is the Kaufmann et al (2009) composite governance indicator.

### A1.5 Performance indices

A class of allocative performance indices, which includes IPI, API and RPI, is defined according to the following general formula:

$$I = \frac{1}{A} \sum w_i A_i \quad (\text{A5.1})$$

The differential of equation (A5.1) is given by

$$dI = \sum \left[ w_i - \frac{\sum w_i A_i}{A} \right] \frac{dA_i}{A} \quad (\text{A5.2})$$

The response to a marginal reallocation of aid from  $n$  to  $m$  is therefore:

$$dI = (w_m - w_n) \cdot \frac{dA_m}{A} \quad (\text{A5.3})$$

For the IPI, the weights are given by:

$$w_i = \frac{y_{\max} - y_i}{y_r} \quad (\text{A5.4})$$

The response of the IPI to a marginal reallocation of aid from  $n$  to  $m$  is therefore:

$$dI = \frac{y_n - y_m}{y_r} \cdot \frac{dA_m}{A} \quad (\text{A5.5})$$

Equation (A5.5) shows that a progressive (regressive) reallocation will always raise (lower) the IPI, i.e. improve (worsen) performance, so income sensitivity is satisfied. Population and policy sensitivity are not satisfied because if two recipients have the same income per capita, a reallocation does not affect the index.

For the RPI, the weights are given by:

$$w_i = \frac{G_i - G_{\min}}{G_r} \cdot \frac{y_{\max} - y_i}{y_r} \quad (\text{A5.6})$$

The response of the RPI to a marginal reallocation from  $n$  to  $m$  is therefore:

$$dI = \frac{(G_m - G_{\min})(y_{\max} - y_m) - (G_n - G_{\min})(y_{\max} - y_n)}{G_r y_r} \frac{dA_m}{A} \quad (\text{A5.7})$$

If  $G_m = G_n$ , equation (A5.7) simplifies to:

$$dI = \frac{(G_m - G_{\min}) \cdot (y_n - y_m)}{G_r y_r} \frac{dA_m}{A} \quad (\text{A5.8})$$

In this case, a progressive (regressive) reallocation will raise (lower) the RPI, unless both recipients have the minimum level of policy. Thus apart from this one exception, income sensitivity is satisfied. Population sensitivity is not satisfied because if  $G_m = G_n$  and  $y_m = y_n$ , a reallocation has no impact on the index. If  $y_m = y_n$  but  $G_m \neq G_n$ , equation (A5.7) simplifies to:

$$dI = \frac{(y_{\max} - y_m) \cdot (G_m - G_n)}{G_r y_r} \frac{dA_m}{A} \quad (\text{A5.9})$$

In this case, a reallocation to a recipient with better (worse) policy will raise (lower) the RPI, unless both recipients have the maximum level of income per capita. Thus apart from this one exception, policy sensitivity is satisfied.

For the API, the weights are given by:

$$w_i = \frac{N_i / y_i - (N / y)_{\min}}{(N / y)_r} \quad (\text{A5.10})$$

The response of the API to a marginal reallocation from  $n$  to  $m$  is therefore:

$$dI = \frac{1}{(N / y)_r} \left( \frac{N_m}{y_m} - \frac{N_n}{y_n} \right) \frac{dA_m}{A} \quad (\text{A5.11})$$

If  $N_n = N_m$ , equation (A5.11) simplifies to:

$$dI = \frac{N_m}{(N / y)_r} \left( \frac{1}{y_m} - \frac{1}{y_n} \right) \frac{dA_m}{A} \quad (\text{A5.12})$$

In this case, a progressive (regressive) reallocation will always raise (lower) the API. Thus income sensitivity is met. Policy sensitivity is not met because if  $N_m = N_n$  and  $y_m = y_n$ , a reallocation has no impact on the index. If  $y_m = y_n$  but  $N_m \neq N_n$ , equation (A5.11) simplifies to:

$$dI = \frac{N_m - N_n}{(N / y)_r y_m} \frac{dA_m}{A} \quad (\text{A5.12})$$

Thus population sensitivity is met.

An alternative class of performance indices, which includes the MPI, is defined according to the following general formula:



$$I' = \frac{1}{\hat{a}} \sum w_i \hat{a}_i \quad (\text{A5.13})$$

The differential version of equation (A5.13) is given by:

$$dI' = \sum \left[ \frac{w_i}{N_i} - \frac{1}{N_i} \frac{\sum w_i \hat{a}_i}{\hat{a}} \right] \frac{dA_i}{\hat{a}} \quad (\text{A5.14})$$

The effect of a reallocation from  $m$  to  $n$  is given by:

$$dI' = \sum \left[ \frac{w_m}{N_m} - \frac{w_n}{N_n} - \frac{\sum w_i \hat{a}_i}{\hat{a}} \left( \frac{1}{N_m} - \frac{1}{N_n} \right) \right] \frac{dA_m}{\hat{a}} \quad (\text{A5.15})$$

For the MPI, the weights are given by:

$$w_i = \frac{y_{\max} - y_i}{y_r} \quad (\text{A5.16})$$

The response of the MPI to a reallocation from  $n$  to  $m$  is therefore:

$$dI' = \frac{1}{y_r} \left[ \left( \frac{y_n}{N_n} - \frac{y_m}{N_m} \right) + \hat{y} \left( \frac{1}{N_m} - \frac{1}{N_n} \right) \right] \frac{dA_m}{\hat{a}} \quad (\text{A5.17})$$

where  $\hat{y} = \frac{\sum \hat{a}_i y_i}{\hat{a}}$ . If  $N_m = N_n$ , equation (A5.17) simplifies to

$$dI' = \frac{y_n - y_m}{y_r N_n} \cdot \frac{dA_m}{\hat{a}} \quad (\text{A5.18})$$

In this case, a progressive (regressive) reallocation will always raise (lower) the MPI, so income sensitivity is met. Policy sensitivity is not met because if  $N_m = N_n$  and  $y_m = y_n$ , a reallocation has no impact. If  $y_m = y_n$  but  $N_m \neq N_n$ , equation (A5.17) simplifies to:

$$dI' = \frac{\hat{y} - y_m}{y_r} \left( \frac{1}{N_m} - \frac{1}{N_n} \right) \frac{dA_m}{\hat{a}} \quad (\text{A5.19})$$

Depending on whether  $\hat{y} - y_m$  is positive or negative, a reallocation to a larger recipient can raise or lower the MPI; likewise for a reallocation to a smaller recipient. Thus population sensitivity is not met.

### A1.6 A new measure

The GPI is defined according to equation (A5.1) above, with recipient country weights given by:

$$w_i = \lambda_1 \left( \frac{N_i - N_{\min}}{N_{\text{range}}} \right) + \lambda_2 \left( \frac{G_i - G_{\min}}{G_{\text{range}}} \right) + \lambda_3 \left( \frac{y_{\max} - y_i}{y_{\text{range}}} \right) \quad (\text{A6.1})$$

The response to a marginal reallocation of aid from  $n$  to  $m$  is therefore:

$$dI = \left[ \frac{\lambda_1}{N_r} (N_m - N_n) + \frac{\lambda_2}{G_r} (G_m - G_n) + \frac{\lambda_3}{y_r} (y_n - y_m) \right] \frac{dA_m}{A} \quad (\text{A6.2})$$

Thus income, population and policy sensitivity are all met as long as  $\lambda_1, \lambda_2, \lambda_3 > 0$ .