On Reckoning Level Differentials in the Measurement of Progress: An Illustration in the Context of Deliveries Assisted by Skilled Health Personnel

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ABSTRACT

The paper highlights that performance assessments should account for non-linear dynamics of progress, whereby an improvement at a higher level represents greater achievement than an equal improvement at a lower level. With this rationale, desirable properties of progress assessment indicators are reviewed and an alternative level-sensitive indicator is discussed. Further, an application in the context of proportion of births attended by skilled health personnel is presented, to draw attention towards the dismal performance of developing regions, particularly least developed countries (LDC) from sub-Saharan Africa and South Asia. In concluding, we argue that post-2015 goal setting should resolve the definitional and operational inconsistencies associated with existing developmental targets and indicators.

Keywords: MDGs, level sensitivity, skilled health personnel, progress assessment, developing region, LDCs

1 INTRODUCTION

Progress assessment is an integral part of policy review and analysis. Commonly, methods such as rate ratios and rate differentials are applied to assess inter-temporal, inter-regional, and inter-group progress. However, an indiscriminate application of these methods is increasingly identified as an area of concern (Nathan and Mishra 2013; Hailu and Tsukada 2011; Fukuda-Parr et al. 2013; Easterly 2009; Subramanian 2008a; Osório 2008; Houweling et al. 2007; Mishra and Subramanian 2006; Kakwani 1993; Sen 1981). It seems useful to briefly illustrate these apprehensions.

Suppose in a given year country X improves immunisation coverage (an indicator of achievement) from 40 per cent to 60 per cent, and country Y increases it from 80 per cent to 100 per cent. Although immunisation has increased by 20 percentage points in both countries, a measure such as rate ratio obtains a value of 0.5 (i.e. 60/40 – 1) for country X, indicating a 50 per cent increase, but 0.25 (i.e. 100/80 – 1) for country Y, or a 25 per cent increase in coverage from the base value. In other words, the use of rate ratio suggests that country X has performed twice as well as country Y, whereas the rate difference (i.e. 60-40 = 100-80 = 20) suggests that progress of country Y is as good as that of country X.

Similarly, consider another case: country A has increased immunisation coverage from 20 per cent to 25 per cent, and country B has increased it from 40 per cent to 50 per cent. Now, in both countries, immunisation has increased by a factor of 0.25 [i.e. (25/20 – 1) = (50/40 – 1)], indicating a 25 per cent increase in coverage from the base level values. However, in terms of rate difference, country B has achieved a greater absolute increase in coverage of 10 percentage points than country A (5 percentage points), thereby ranking ahead of country A in any progress rankings. With this simple example, it is obvious that varying levels of the developmental indicator presents considerable scope for arbitrariness and conflicting inferences in progress assessments (Easterly 2009; Houweling et al. 2007; Moser et al. 2007). Therefore, it is critical to resolve such intricacies by relying on progress-related inferences from methods that explicitly account for the base level differentials in the developmental indicator. With this objective, this note aims to highlight the inherent concerns pertaining to level sensitivity and also reviews alternative indicators to facilitate level-sensitive progress assessments.

Among others, progress towards the Millennium Development Goals (MDG) is an important area for applications for such level-sensitive progress assessments. As such, the MDGs were meant to mobilise international commitment towards developmental goals, but have been misinterpreted and misappropriated by different groups as region- or sector-specific goals (Vandemoortele and Delamonica 2010; Tabatabai 2007). Nevertheless, one of the lessons emerging from these indiscriminate assessments of MDGs has direct relevance for progress assessments. For instance, most MDG studies have increasingly recognised that several countries and regions (particularly Africa) were unable to progress much during the 2000s because of varying base levels and developmental constraints. In other words, such findings reveal the importance of accounting for the non-linear dynamics of improvement at different levels (Easterly 2009; Osório 2008; Vandemoortele 2009; Vandemoortele and Delamonica 2010; Addison et al. 2005). In fact, it is argued that an improvement at a higher level represents greater achievement than an equal improvement at a lower level[1] (Waage et al. 2010; Fukuda-Parr et al. 2013; Prennushi et al. 2002; Sen 1981; Dasgupta 1990; Kakwani 1993). Particularly at higher levels, the marginal social cost for improvement increases disproportionately. This implies that commitment towards universal coverage in a given dimension is generally a major policy concern in goal setting and resource allocation practices.

Given such equity–efficiency trade-off, countries are more likely to prefer a utilitarian approach (over rights-based approach for universal coverage) and redirect the additional investment to areas with greater net benefits. As observed by the Lancet Commission[2] on the MDGs (Waage et al. 2010), health officials in developing countries often face such dilemmas. Given such intricacies, it is important to engage with level-sensitive assessments to acknowledge the commitment of countries that continue to progress despite lower net benefits. Moreover, such level-sensitive assessments appreciate that higher frontiers could be reached through sustained action against inter-sectoral problems associated with social and political determinants. Importantly, the case for level sensitivity is also linked to an intrinsic concern for equity. For instance, prominent developmental goals such as the MDGs focus on access to minimum levels of provision in health, education, or earnings, but they do not go far enough to address inequities associated with crossing a line of minimum adequacy (Waage et al. 2010). In this context, continued progress of countries at higher levels reflects

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[1] Some contrasting views are also noted regarding plausible non-linearity while assessing poverty reductions. For instance, in the context of MDGs, Easterly (2009) argues that it may be rather difficult to reduce poverty levels in Africa because of much lower per capita incomes and weak poverty elasticity of growth; whereas Prennushi et al. (2002) notes that *[A]s a general rule, performances become more difficult as levels improve and it is generally more difficult to reduce income poverty from 10 percent to 0 than from 40 percent to 30 percent, because the target group generally becomes more difficult to reach* (cited in Hailu and Tsukada 2011).

[2] The Lancet Commission specifically argues (Waage et al. 2010: 1018): *Short of 100% coverage, there are no absolutes. A country might be faced with a real choice of either spending the available funds trying to get 100% coverage, or accepting that 80% is quite good, and electing to use the available funds to introduce a new vaccine, such as that for rotavirus. The utilitarian approach would argue that the net benefits are greater if the new vaccine is introduced into the 80% of people already covered, whereas the rights-based approach would argue that the 20% of children have a right to routine vaccines and should be the first priority. At higher levels of coverage this dilemma might become even more difficult as the cost of immunising a small number of unimmunised children might become very high, if, for example, a helicopter is needed to reach some small isolated settlements. This dilemma is familiar to health officials in developing countries. Although there might be no right or wrong answers, a real analysis of the costs and benefits of various approaches would empower countries to make more reasoned decisions.*

commitment towards wellbeing for all,[3] and should be rewarded because it maximises benefits for a society and is expected to reduce absolute inequalities[4] across socio-economic and geographical sub-groups in the given dimension.

With this underlying rationale, the subsequent sections of the paper adopt an axiomatic approach to review the existing methods for progress assessment (Section 2) and discuss an alternative level-sensitive indicator that satisfies the desirable properties (Section 3). Section 4 presents an empirical illustration to compare the findings from the suggested level-sensitive indicator with that of the most common progress assessment indicators: rate differences (absolute change) and rate ratios (percentage change). The concluding Section 5 draws attention towards this prominent concern of lower proportions of deliveries assisted by skilled health personnel across least developed countries (LDCs) and argues for an explicit focus on improving quality and coverage in the post-2015 'sustainable' developmental goals.

2 LEVEL-SENSITIVE PROGRESS ASSESSMENT

Let h be an indicator denoting average health attainment of a particular region or socio-economic group with a_h and b_h as the lower and upper bounds of the health variable, respectively. For convenience, the health statistic is presented as proportions ($0 \leq h \leq 1$) with $a_h = 0$ and $b_h = 1$. Furthermore, let t denote the time period with $t_i = (t_1, t_2, \ldots, t_n)$. For example, h represents average health achievements (such as average immunisation coverage) expressed as a proportion ranging between ($0 \leq h \leq 1$) whereas t_1 and t_2 can be conceived as years, say 1990 and 2000, respectively. Now, the progress assessment index for health attainment (h) between two time points, t_1 and t_2, can be denoted by $P(h)$.

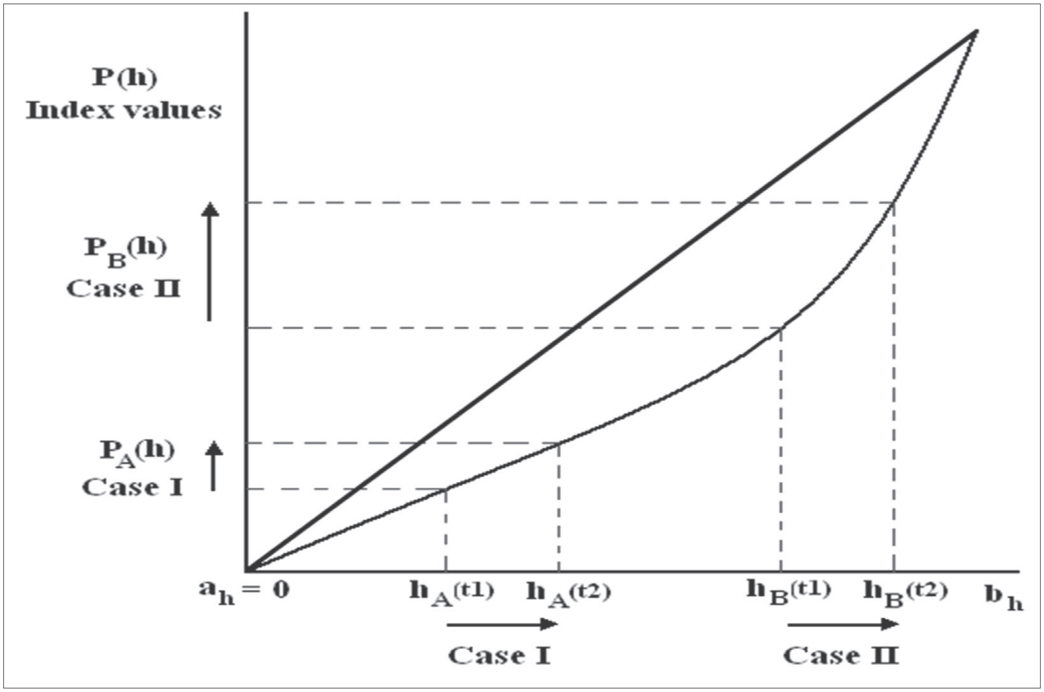
Importantly, $P(h)$ is expected to demonstrate level sensitivity, as exhibited in Figure 1. The x-axis plots levels of health achievement (h) and the y-axis presents the progress index values, $P(h)$, during time period t_1 and t_2. The continuous curve beginning from the lower bound (a_h) depicts the notion of level sensitivity that any progress assessment indicator should display. In the case of health achievement (h), a convex curve implies that the progress index

[3] It is increasingly acknowledged that developmental outcomes are influenced by multiple socio-economic and contextual determinants. Intersections of these determinants produce a complex synergy that makes it increasingly difficult at higher levels to secure further improvement. For instance, rural areas may initially show improvement in health care coverage (say immunisation) but greater efforts are required to improve coverage among inter-sectional groups such as vulnerable socio-economic groups (backward caste or tribal groups) residing in remote or under-served areas (Joe 2014).

[4] For instance, the inverse equity hypothesis postulated by Victora et al. (2000) suggests that increasing health care coverage could be associated with a greater reduction in inequity ratios, as with improving levels the poor are likely to gain greater access to interventions. In fact, empirical evidence from India suggests an inverse relationship between immunisation levels and wealth-related relative inequalities in immunisation, thus depicting a more likely complementary association between health equity and efficiency (Pande and Yazbeck 2003; Gaudin and Yazbeck 2006).

values, $P(h)$, should be greater for similar achievements, occurring at higher level of health achievement than compared to lower levels. For instance, the rate difference between health achievements is similar in both Cases I and II, i.e., $h_A(t_2) - h_A(t_1) = h_B(t_2) - h_B(t_1) = \Delta h$. Now, the 45-degree straight line from the lower bound ($a_h = 0$) depicts a case where equal achievements are valued equally irrespective of the level of the achievement. However, the allowance for level sensitivity necessitates that the value for $P(h)$ is greater for Case II than Case I, because the same improvements in Case II are associated with higher levels. As outlined in the introductory section, the level-sensitive behaviour assumed here is consistent with equity impacts and the notion of increasing marginal cost with higher levels of attainment .

Figure 1 Level sensitivity in progress assessment



The rest of this section reviews the various progress indices by invoking certain desirable axiomatic properties for an indicator of progress assessment (Kakwani 1993; Mishra and Subramanian 2006; Nathan and Mishra 2013).

Normalisation It is convention that $-1 \leq P(h) \leq +1$, where positive values of the index indicate progress or improvements in average health between two time points (t_1, t_2); negative values indicate deterioration or worsening of average health; and 0 indicates neither progress nor deterioration. Besides, higher the value, higher the magnitude of progress.

Monotonocity This axiom necessitates the progress index $P(h)$ to be an increasing function of h. The corollary *minimality* demands that the progress index $P(h)$ should be greater than 0 if $\Delta h = h(t_2) - h(t_1) > 0$ whereas *maximality* requires the index $P(h)$ to be less than 1 if $\Delta h = h(t_2) - h(t_1) < 1$.

Translation invariance This condition requires the index $P(h)$ to be independent of any positive proportional transformation (such that $\mu_{\hat{h}} = \beta\mu_h$, $a_{\hat{h}} = \beta a_h$ and $b_{\hat{h}} = \beta b_h$ with $\beta > 0$) would not affect the value of the progress index i.e., $P(h) = P(\hat{h})$.

Difference-based level sensitivity Whenever the absolute change in h is equal (i.e., $\Delta h = h^X(t_2) - h^X(t_1) = h^Y(t_2) - h^Y(t_1)$) across two contexts X and Y *with* $h^X(t_1) > h^Y(t_1)$, the context with higher base level should register a greater index value $P(h)$, i.e. $P^X(h) > P^Y(h)$.

Ratio-based level sensitivity Across two contexts X and Y *with* $h^X(t_1) > h^Y(t_1)$, w*henever* $h^X(t_2)/h^X(t_1) = h^Y(t_2)/h^Y(t_1)$), the context with higher base level should register a greater index value $P(h)$ i.e, $P^X(h) > P^Y(h)$.

Additivity The progress between two time periods must be equal to the sum of progress of its sub-periods. For example, if $\Delta h^Z = h(t_3) - h(t_1)$; $\Delta h^A = h(t_2) - h(t_1)$; and $\Delta h^B = h(t_3) - h(t_2)$, then $P(h^Z) = P(h^A) + P(h^B)$.

Given the desirable properties, a progress index can be defined by the following general expression:

$$P(h) = f(a_h, b_h, h(t_1), h(t_2))\Delta h \quad (1)$$

where f(.) is a continuous function; h is the health variable which is bounded in nature with a_h and b_h as the lower and upper bounds of the health indicator, respectively. $\Delta h = h(t_2) - h(t_1)$ is difference in the average health status between the two time points. Following expression (1), some common progress indices are described as follows:

$$D(h) = h(t_2) - h(t_1) = \Delta h \quad (2)$$

$$R(h) = [h(t_2) - h(t_1)]/h(t_1) = \Delta h/h(t_1) \quad (3)$$

$$S(h) = [h(t_2) - h(t_1)]/[b_h - h(t_1)] = \Delta h/[b_h - h(t_1)] \quad (4)$$

$$MS(h) = [h(t_2)]^{\alpha}/[h(t_1)]^{\alpha+1}; \text{ where } \alpha > 0 \quad (5)$$

$$NM(h) = [h(t_2) - h(t_1)]/[b_h - \lambda h(t_1)] = \Delta h/[b_h - \lambda h(t_1)]; \text{ where } 0 \geq \lambda \geq 1 \quad (6)$$

$$K(h_1) = [(b_h - h(t_1))^{1-\varepsilon} - (b_h - h(t_2))^{1-\varepsilon}]/(b_h - a_h)^{1-\varepsilon} \text{ if } 0 < \varepsilon < 1 \quad (7)$$

$$K(h_2) = [\mathrm{Ln}(b_h - h(t_1)) - \mathrm{Ln}(b_h - h(t_2))]/\mathrm{Ln}(b_h - a_h) \text{ if } \varepsilon = 1 \quad (8)$$

$D(h)$ is based on a simple rate differential. Given the general expression, it is clear that f(.) = 1, thus providing equal weight to progress irrespective of base level differentials. This implies that the rate differential indicator will not exhibit level sensitivity as, for instance, the effort leading to a decrease in infant mortality rate from 80 per 1000 live births to 70 per 1000 live births will be considered as good as the effort required for a decrease from 40 per 1000 live births to 30 per 1000 live births. However, in the case of rate ratios, $R(h)$, the weighting function $f(.) = 1/h(t_1)$ makes the index level-sensitive. But the weights are such that regions or groups with higher base level value $h(t_1)$ would receive lower weights for a given Δh. This is in contrast to the level-sensitive behaviour suggested here, that improvements at higher levels should receive greater weights. By Sen's (1981) index, $S(h)$ has $f(.) = 1/(b_h - h(t_1))$, and attaches greater weight to a given Δh, as desired. Similarly, two other measures of level-sensitive differentials—$MS(h)$, advanced in Mishra and Subramanian (2006), and $NM(h)$, advanced in Nathan and Mishra (2013)—satisfy level sensitivity and can be adapted for progress assessment. The weighting function implicit in $NM(h)$ is $f(.) = 1/(b_h - \lambda h(t_1))$. It is discernible that when λ=1, then $NM(h) = S(h)$, and when λ=0.5, the relation between $NM(h)$ and Sen's index $S(h)$ can be written as follows:

$$S(h) = \{[2b_h - h(t_1)]/[2(b_h - h(t_1))]\} \times NM(h) \qquad (9)$$

$S(h)$ and $NM(h)$ display *policy sensitivity,* implying that the index values would be at least as high as the absolute gap between the two time points i.e., $P(h) \geq \Delta h$ (Subramanian 2004; Nathan and Mishra 2013). However, these indices do not satisfy *additivity,* implying that progress between two time periods cannot be expressed as a sum of progress between its sub-periods. In fact, as $\Delta h \rightarrow 1$, *the* requirements of policy sensitivity, additivity, and normalisation could be incompatible.

For a simple illustration, assume three time periods in sequence: t_1, t_2, and t_3. Let $\Delta h^A = h(t_2) - h(t_1)$; $\Delta h^B = h(t_3) - h(t_2)$ with $\Delta h^A = \Delta h^B = 0.5$. *Now any policy sensitive index of progress would demand* $P(\Delta h^B) > 0.5 \geq P(\Delta h^A)$ *implying that* $P(\Delta h^B) + P(\Delta h^A) > 1$, *thus violating normalisation.* Interestingly, $K(h)$, fulfils *additivity* but Kakwani (1993) suggests two different progress indices depending on the value of parameter (see $K(h)$ index in equation 7 and 8). Also, like $MS(h)$, the weights attached to a given differential Δh in $K(h)$ is not explicit. Furthermore, to ensure level sensitivity, the index $K(h_2)$ relies on a logarithmic transformation of the indicator, h, and can be problematic whenever $h < 1$. Besides, a further glance at the denominator of $K(h_2)$, informs that the index also violates *translation invariance*. Instead, under such conditions, $K(h_1)$ is a better alternative. Given some of the major limitations of the above indices, it is only reasonable to identify a progress index, $P(h)$, that satisfies desirable axiomatic requirements and can be used with any h that lies on the real line, R.

3 ACHIEVEMENT AND PROGRESS INDICES

Following Kakwani (1993) and Subramanian (2008a), we discuss the achievement function first, and then derive the progress index as the difference between the values of the achievement function in the two periods. Let $g(a_h, b_h, h)$ be the achievement function that assumes a value of 0 if $h = a_h$ and equals 1 when $h = b_h$. A progress index, $P(h)$, is then defined as:

$$P(h) = f(a_h, b_h, h(t_1), h(t_2))\Delta h = g(a_h, b_h, h(t_2)) - g(a_h, b_h, h(t_1)) \qquad (10)$$

While deciding upon the specification for g(.), it is critical that $P(h)$ is an increasing function of $h(t_2)$ and a decreasing function of $h(t_1)$. In other words, a level-sensitive achievement function must be a convex function, as it allows the achievement to increase at a faster rate for a progressive change in the health indicator. For this purpose, following[5] Subramanian (2008a), we employ a convex achievement function, $A(h)$:

$$A(h) = [(b_h - a_h)h]/[2(b_h - a_h) - h] \qquad (11)$$

$A(h)$ ranges from 0 to 1.Since a further increase in health achievement at higher levels should be valued more, it is critical that $g(h) > 0$, $g'(h) > 0$, $g''(h) > 0$ and $g(h) = 0$ if $h = 0$.Given that $g(h) = [(b_h - a_h)h]/[2(b_h - a_h) - h]$. Let $(b_h - a_h) = \delta$; then, $g(h) = (\delta h)/(2\delta - h)$; $g'(h) = 2\delta^2/(2\delta - h)^2$; $g''(h) = 4\delta^2/(2\delta - h)^4$. Since $2\delta > h$, therefore the denominator in g(.) is positive and it follows that $g(h) > 0$, $g'(h) > 0$ and $g''(h) > 0$.

Using $A(h)$, a progress index[6] $P(h)$ that satisfies *normalisation*, *monotonocity*, *translation invariance*, *difference-based level sensitivity*, *ratio-based level sensitivity*, and *additivity* can be expressed as the difference between the values of the achievement function in the two periods as follows (see the appendix for proof):

$$P(h) = \frac{2(b_h - a_h)}{[2(b_h - a_h) - h(t_2)][2(b_h - a_h) - h(t_1)]} \times \Delta h \qquad (11)$$

Further, following the translation invariance property, and by assuming $a_h = 0$, it can be shown that a bounded health average h can be standardised and defined as $h^* = (h/b_h)$ such that $a^* = 0$ and $b^* = 1$. With this standardisation, the progress index $P(h^*)$ can be expressed as:

$$P(h^*) = \frac{2}{[2 - h^*(t_2)][2 - h^*(t_1)]} \times \Delta h^* \qquad (11)$$

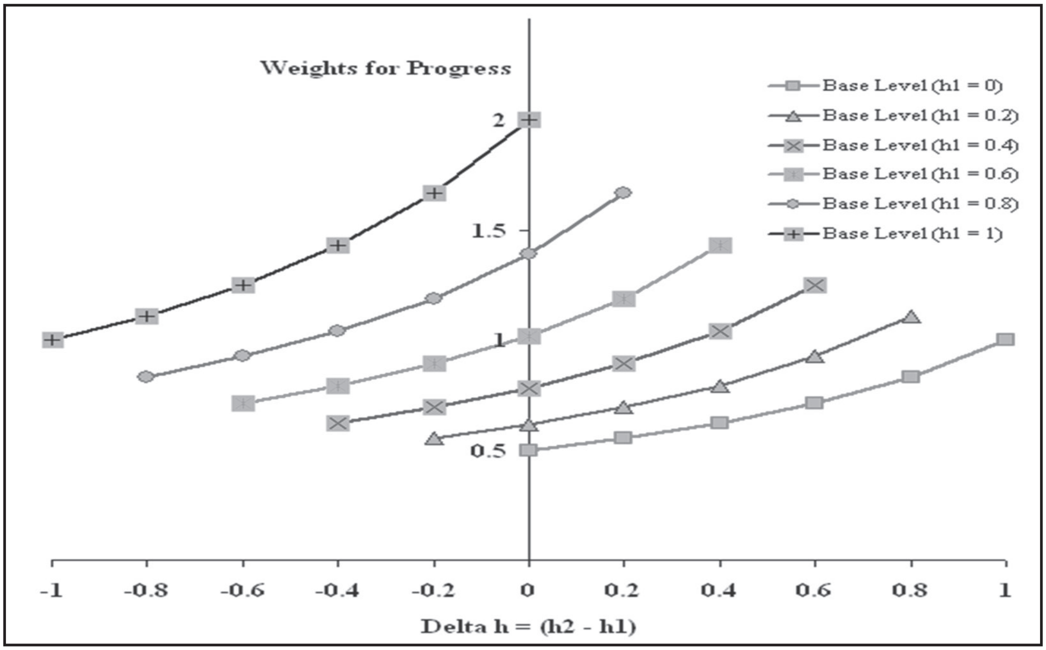
[5] It may be noted that Atkinson's (1970) social welfare function is used in Kakwani (1993) to develop the convex achievement function. Similarly, the achievement function A(h) is related with the Gini coefficient defined for a binary valued (0 or 1) distribution. Such a distribution can be obtained whenever health distributions are standardised to lie between 0 and 1. It is easily verifiable that for any such distribution with mean h, the Gini coefficient G(h) is given by 1-h (Subramanian 2008b). Since 1+G(h) = 1 + (1-h) = (2-h), it is obvious that the convex achievement function h/(2-h) essentially discounts the average of the standardised health distribution using the Gini coefficient.

[6] P(h) and NM(h) share the following relationship: $P(h) = (2(b_h - a_h) - h(t_2)) \times NM(h)$

The progress index P(h*) in (13) can be used for all practical purposes, as most developmental indicators can be standardised and expressed in proportions ($0 \leq h^* \leq 1$).However, before proceeding with an application, it is worthwhile to graphically depict the weighting function associated with P(h).

Figure 2 plots the weighting function f(.) underlying P(h) for each plausible (Δh) associated with a standardised health achievement variable and with varying base levels $h(t_1)$. The weights are represented on the y-axis and with varying Δh on the x-axis. It is clear that for a given base level $h(t_1)$, higher weights are always received for greater improvements. Also, it can be verified that for a given level of change (Δh), cases with higher base levels $h(t_1)$ receive greater weights.

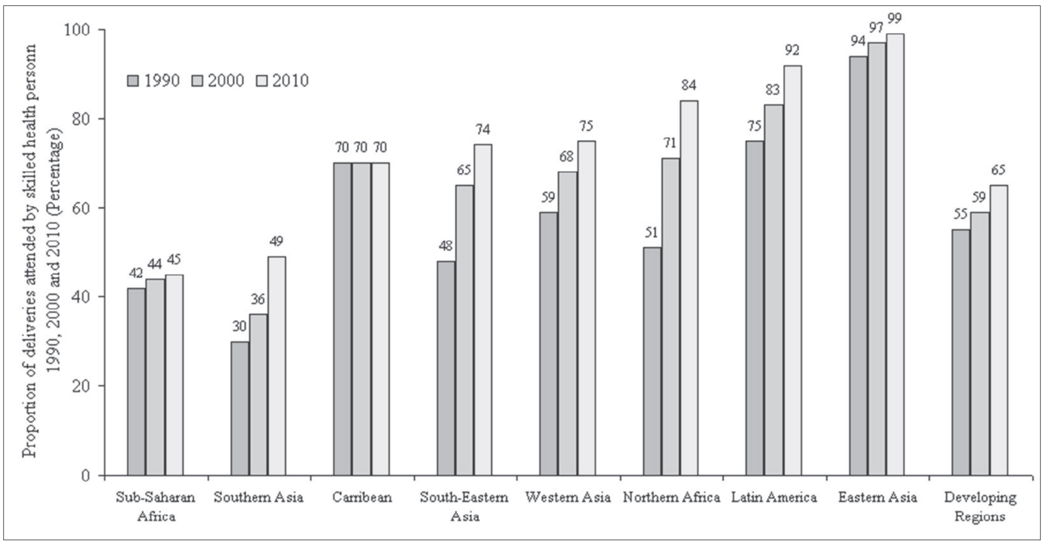
Figure 2 Weighting function describing social valuation of progress



4 AN APPLICATION: DELIVERIES ASSISTED BY SKILLED HEALTH PERSONNEL

It is widely acknowledged that deliveries assisted by skilled health personnel are instrumental in reducing the risk of maternal death or disability by preventing or managing life-threatening complications (UN 2013). Because of its relevance for promoting safe motherhood, this indicator is also regarded as a suitable proxy to understand progress towards MDG 5 (reducing maternal mortality). Importantly, increments in proportion of deliveries assisted by skilled health personnel broadly reflect the improvement in access to health care facilities and can favourably impact neonatal and child survival. However, MDGs and their indicators are not explicit on the concern of neonatal mortality, and do not focus on its association with deliveries attended by skilled health personnel. But recent observations regarding a growing share of neonatal deaths in overall under-five deaths, as well as a slow pace of decline in neonatal mortality, has received global attention (see, for instance, UN 2013). In this regard, this empirical illustration reiterates the importance of skilled health personnel and calls for an explicit focus on its quality and coverage in post-2015 goal setting. The UN MDG Report 2012 informs that in developing regions, the proportion of deliveries attended by skilled health personnel improved from 55 per cent in 1990 to 65 per cent in 2010 (UN 2012). As shown in Figure 3, sub-Saharan Africa and South Asia continue to have the lowest proportion of deliveries attended by skilled health personnel during the past two decades (1990, 2000, and 2010).

Figure 3 Proportion of deliveries attended by skilled health personnel in developing regions, 1990, 2000, and 2010 (percentage)



Source: United Nations (2012)

Disconcertingly, sub-Saharan Africa does not show any significant inter-temporal improvements in the proportion of deliveries attended by skilled health personnel—they attended only 42 per cent of the births in 1990 and around 45 per cent in 2010. Data inadequacies notwithstanding, this dismal progress indicates the persistent developmental problems of the health systems in sub-Saharan Africa. Coverage was the lowest in South Asia during 1990, but has improved in the past two decades; despite this, 51 per cent of the births in 2010 took place in the absence of skilled health personnel. Given South Asia's population share, such gaps in health care coverage can easily translate into a higher burden of maternal and child mortality for South Asian countries, particularly India. On the other hand, East Asia and Latin America have performed well during the 1990s and 2000s, and it is only expected that these regions aim at universal coverage. As regards inter-temporal progress, the case of Northern Africa is notable, as it has improved its performance from 51 per cent in 1990 to 84 per cent in 2010, and outperformed Southeast Asia, which had reported similar coverage during 1990 but lagged behind in 2010.

Table 1 facilitates an inter-temporal comparison to understand if the MDG Declaration could be associated with accelerated progress after 2000 (see, for instance, Fukuda-Parr et al. 2013). For comparisons, three indicators of progress are applied:

1. rate differential $[D(h) = h(t_2) – h(t_1) = \Delta h]$;
2. rate ratio $[R(h) = \{h(t_2)/h(t_1) – 1\}*100]$; and
3. progress index $P(h) = [2\Delta h/\{(2- h(t_2)) – (2-h(t_1))\}]$.

These three indicators of progress are based on three different weighting principles for the level differentials. Under rate differential D(h), each unit of improvement in coverage will receive equal weights, irrespective of the base level. Through the rate ratio R(h), each unit of improvement from a lower base level would receive greater weights than a similar improvement at a higher base level; whereas, in the progress index P(h), each unit of improvement at a higher base level would receive greater weights than a similar improvement at a lower base level. These differences in weighting structure are relevant in commenting upon if the MDG Declaration has accelerated developmental progress. For example, assume that a region has improved its performance from 40 per cent in 1990 to 50 per cent in 2000 and further to 60 per cent in 2010. It is obvious that the absolute progress during the 1990s and the 2000s is the same; and that, therefore, a measure such as the rate difference would yield the same value of 10 per cent for both periods. Also, the measure would suggest that the region performed as well (or poorly) in the 2000s as it did in the 1990s. However, a measure such as the rate ratio would suggest that the region performed 1.25 times[7] better in the 1990s as in the 2000s, and that progress slowed down in the 2000s. In contrast, a level-sensitive progress index would reveal that the region performed 1.14 times better during the 2000s.We acknowledge that progress may become increasingly difficult with improvement; therefore, basing inferences on the rate ratio in this example may give us a rather pessimistic picture of progress during the 2000s. On the contrary, a level-sensitive indicator such as the P(h)suggests that progress during the 2000s was not as discouraging as suggested by rate differentials and rate ratios.

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7 Rate ratio (1990s) = 50/40 – 1 = 0.25; rate ratio (2000s) = 60/50 – 1 = 0.20.Therefore, performance in 1990s is 1.25 times better (0.25/0.20 = 1.25).The progress index values for 1990s and 2000s are 0.083 and 0.095, respectively. Therefore, performance is 1.14 times better (0.083/0.095 = 1.14) during 2000s.

Table 1 Proportion of deliveries attended by skilled health personnel across developing regions, progress assessment using rate difference, rate ratio, and progress index, 1990, 2000, and 2010

	Rate differential, D(h)			Rate ratio, R(h) (%)			Progress index, P(h)		
Regions	1990-2000	2000 2010	1990 2010	1990 2000	2000 2010	1990 2010	1990 2000	2000 2010	1190 2010
Sub-Saharan Africa	2	1	3	4.8	2.3	7.1	0.016	0.008	0.024
Southern Asia	6	13	19	20.0	36.1	63.3	0.043	0.105	0.148
Caribbean	0	0	0	0.0	0.0	0.0	0.000	0.000	0.000
South-Eastern Asia	17	9	26	35.4	13.8	54.2	0.166	0.106	0.272
Western Asia	9	7	16	15.3	10.3	27.1	0.097	0.085	0.182
Northern Africa	20	13	33	39.2	18.3	64.7	0.208	0.174	0.382
Latin America	8	9	17	10.7	10.8	22.7	0.109	0.142	0.252
Eastern Asia	3	2	5	3.2	2.1	5.3	0.055	0.038	0.093
Developing Regions	4	6	10	7.3	10.2	18.2	0.039	0.063	0.102

Note: For progress assessment, information regarding proportions of deliveries attended by skilled health personnel is normalised to range from 0 to 1.

D(h) is Rate difference computed as $[D(h) = h(t_2) – h(t_1) = \Delta h]$; R(h) is Rate ratio computed as $[R(h) = \{h(t_2)/h(t_1) – 1\}*100]$; and, P(h) is progress index computed as $P(h) = [2\Delta h/\{(2- h(t_2)) – (2-h(t_1))\}]$. In the table, countries are arranged in descending order of the proportion of deliveries attended by skilled health personnel in 2010 (Figure 3).

After clarifying the implicit weighting structure, Table 1 shows only a marginal acceleration after the MDG Declaration in improving the proportion of deliveries attended by skilled health personnel. However, with the exception of South Asia and Latin America, no other developing region has shown any acceleration in progress after 2000. This inference is valid irrespective of the measures adopted for assessment and the underlying weighting principles. The performance of Latin America is interesting and offers an opportunity to discuss further the importance of level-sensitive assessments. Latin America has increased the proportion of deliveries assisted by skilled health personnel from 75 per cent in 1990 to 83 per cent in 2000 and further to 92 per cent in 2010. Therefore, an analysis based on rate difference and rate ratio would infer that the performance during the 2000s is as good as that in the 1990s (see Table 1). However, a level-sensitive progress index for Latin America obtains a relatively high value for the improvements observed during 2000s. This index endorses the idea that such steady progress at higher levels of coverage is expected to be equity enhancing, despite its possibly higher marginal social cost. In this regard, Northern Africa—with considerable progress during the 1990s but a slowdown in the 2000s—is a reasonable example to corroborate the notion that progress becomes increasingly difficult at a higher level. Finally, it can also be discerned from Table 1 that the progress index is additive in nature and, unlike rate ratios, makes it easier to understand the inter-temporal composition of level-sensitive progress between two time points.

The foregoing assessment aimed at presenting an inter-temporal performance of the regions in the last two decades, though without any intention to evaluate the performance against any target or benchmark (such as the MDGs). In fact, it is deemed unfair to engage in a 'progress towards MDGs'-type analysis, as MDG targets are not regional targets, and also because regions have non-comparable and varying developmental constraints (Fukuda-Parr et al. 2013; Easterly 2009; Vandemoortele and Delamonica 2009). Nevertheless, inter-country and inter-regional comparisons are inevitable—partly to unravel the plight of poorly performing regions, and partly to draw the attention of the international developmental community towards inter-regional disparities in the selected developmental indicator. However, we maintain that such inter-regional progress assessments need not necessarily be evaluated from a target perspective (such as the MDGs) but rather as intrinsic to developmental assessment. With this objective, we present an assessment to highlight progress across LDCs in the coverage of births attended by skilled health personnel.

For this analysis, country-level data for LDCs are accessed from the official United Nations website for the MDG indicators (http://unstats.un.org/UNSD/MDG/Data.aspx). A list of 48 countries classified as LDCs is also available from the official website for the MDG indicators. Since annual information regarding births attended by skilled health personnel is not available, data are used for two broad five-year periods (1998–2002 and 2008–2012), and the most recent year's information is analysed to comment on the performance of LDCs after the MDG Declaration. The requirement of data for at least two time points restricts the analytical scope to only 27 LDCs. Based on the data, Table 2 reports the changes in the overall proportion of deliveries attended by skilled health personnel across 27 LDCs during 1998–2002 and 2008–2012. It also presents an assessment of progress using rate difference, rate ratio, and progress index, which embed varying weighting principles, depending on the base level of the indicator.

During 2008–12, the coverage level varied from 95 per cent in Maldives to around 10 per cent in Ethiopia, thus presenting with a wide range of 85 per cent across these 27 LDCs. Importantly, even during 1998–2002, Ethiopia had the lowest coverage of 5.6 per cent, and appears to have improved only marginally since the MDG Declaration. Importantly, among these LDCs, only eight countries have coverage levels below 50 per cent. A glance at the rate differentials between 1998–2002 and 2008–2012 reveals that almost all the 25 LDCs (excluding Kiribati and Madagascar) have shown increments in the proportion of births assisted by skilled health personnel. The highest absolute progress of 41 per cent is observed in Bhutan (from 24 per cent in 1998–2002 to 65 per cent in 2008–2012), and the next highest, 39 per cent, in Cambodia (from 32 per cent in 1998–2002 to 71 per cent in 2008–2012). Consequently, on a progress assessment based on rate differentials, Bhutan and Cambodia are ranked first and second, respectively. However, the performance of countries such as Maldives, which has improved coverage from a high base level of 70 per cent to 95 per cent, is overlooked, as it ranks 7th in the list of 27 LDCs.

Table 2 Proportion of deliveries attended by skilled health personnel across LDCs, progress assessment using rate difference, rate ratio, and progress index, 1998–2002 and 2008–2012

	Deliveries assisted by SBAs (%)		Progress assessment and rankings					
Least Developed Countries*	1998-2002	2008-2012	D(h)	Rank	R(h)	Rank	P(h)	Rank
Cambodia	31.8	71	39.2	2	123%	5	0.361	1
Maldives	70.3	94.8	24.5	7	35%	13	0.359	2
Bhutan	23.7	64.5	40.8	1	172%	3	0.342	3
Rwanda	31.3	69	37.7	3	120%	6	0.341	4
Burkina Faso	31	65.9	34.9	5	113%	7	0.308	5
Burundi	25.2	60.3	35.1	4	139%	4	0.287	6
Benin	65.5	84.1	18.6	11	28%	15	0.239	7
Democratic Republic of the Congo	60.7	80.4	19.7	10	32%	14	0.236	8
Sierra Leone	41.7	62.5	20.8	8	50%	9	0.191	9
Nepal	10.9	36	25.1	6	230%	1	0.162	10
Uganda	39	57.4	18.4	12	47%	10	0.160	11
Myanmar	57	70.6	13.6	13	24%	17	0.147	12
Bangladesh	11.6	31.7	20.1	9	173%	2	0.127	13
Malawi	60.5	71.4	10.9	15	18%	21	0.122	14
United Republic of Tanzania	35.8	48.9	13.1	14	37%	12	0.106	15
Togo	48.6	59.4	10.8	16	22%	19	0.101	16
Central African Republic	44.1	53.8	9.7	17	22%	20	0.085	17
Senegal	58	65.1	7.1	19	12%	22	0.074	18
Guinea-Bissau	34.7	43	8.3	18	24%	16	0.064	19
São Tomé and Príncipe	78.6	81.7	3.1	23	4%	23	0.043	20
Chad	16.3	22.7	6.4	20	39%	11	0.039	21
Timor-Leste	23.7	29.3	5.6	21	24%	18	0.037	22
Ethiopia	5.6	10	4.4	22	79%	8	0.024	23
Gambia	54.7	56.6	1.9	24	3%	24	0.018	24
Lesotho	59.8	61.5	1.7	25	3%	25	0.018	25
Madagascar	46.2	43.9	-2.3	26	-5%	26	-0.019	26
Kiribati	85	79.8	-5.2	27	-6%	27	-0.075	27

Source: The official UN site for the MDG indicators http://unstats.un.org/UNSD/MDG/Data.aspx, accessed on 13 April 2014)

Note: For LDCs list see http://mdgs.un.org/unsd/mdg/Host.aspx?Content=Data/RegionalGroupings.htm.

* For illustrative purposes, only LDCs for which data on proportion of deliveries attended by skilled health personnel was reported for both period 1998-2002 and 2008-2012 are included. Also, information for the most recent year was included in both the time periods for progress assessment. For progress assessment, all the information regarding proportions of deliveries attended by skilled health personnel is normalised to range from 0 to 1. D(h) is Rate difference computed as $[D(h) = h(t_2) – h(t_1) = \Delta h]$; R(h) is Rate ratio computed as $[R(h) = \{h(t_2)/h(t_1) – 1\}*100]$; and, P(h) is progress index computed as $P(h) = [2\Delta h/\{(2- h(t_2)) – (2-h(t_1))\}]$. In the table, countries are arranged in descending order of the ranking in terms of progress index P(h).

Contrastingly, an assessment based on rate ratios finds that Nepal has made a 230 per cent increase in coverage and is, therefore, identified as the best progressing LDC. Given the inference, it may be somewhat surprising to note that Nepal has also progressed by 25 percentage points (from 11 per cent in 1998–2002 to 36 per cent in 2008–2012) but is ranked very differently than Maldives. Further, the rate ratio identifies Bangladesh as the second best performer, for improving coverage from 12 per cent in 1998–2002 to 32 per cent in 2008–2012. Bhutan and Cambodia, which registered the highest absolute improvement, are ranked 3rd and 5th, respectively. Given these rankings, it is obvious that rate ratios share a negative association with the base level of the indicator, and provide much higher weights to improvements occurring at lower levels of the phenomenon (see Figure 4).

Finally, an assessment based on progress index accounts for the level differentials while assessing progress, and reveals that Cambodia deserves to be ranked ahead of other LDCs for its progress in enhancing coverage of births attended by skilled health personnel. Although Bhutan has reported the highest absolute progress, the progress index has ranked it below Cambodia and Maldives, as Cambodia has achieved the progress from a higher level, and thus ensured greater (and perhaps equity enhancing) outreach of health care services. In fact, Cambodia and Maldives obtain very similar progress index values, although the latter is ranked second. Countries such as Nepal and Bangladesh, deemed best progressing countries in terms of rate ratios, are now ranked 10th and 13th, respectively. While both Myanmar and Timor-Leste have similar rate ratio-based rankings, they display significantly different coverage levels. Clearly, the progress index acknowledges such disparities in coverage levels, and ranks Myanmar much ahead of Timor-Leste. Also, while both Maldives and Nepal have attained almost equal absolute progress (25 per cent), Maldives has progressed from a much higher base level; therefore, the progress index ranks Maldives much higher.

Table 3 Rank correlation between progress index, rate ratio, rate difference and proportion of deliveries attended by skilled health personnel across LDCs, 1998–2002

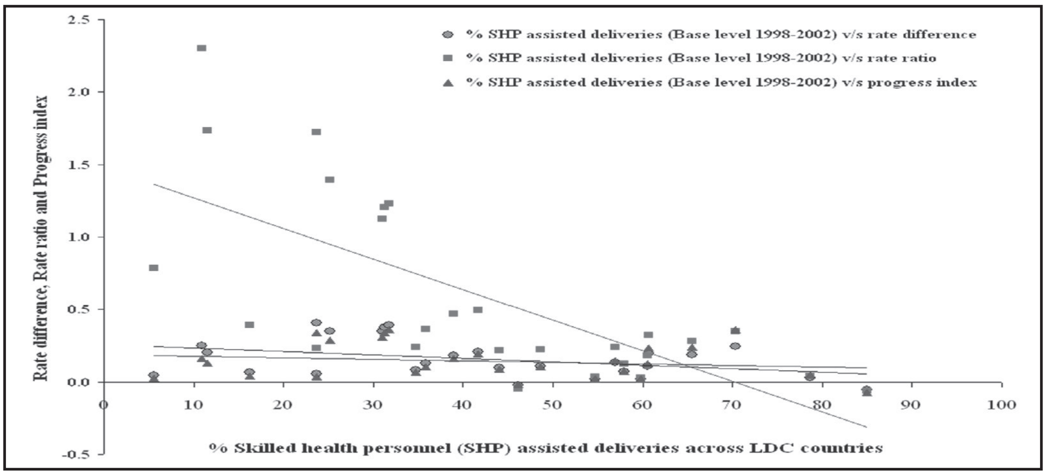
Spearman's rho (N=27)	Deliveries assisted by SBAs (%, 1998–2002)	Rate difference D(h)	Rate ratio, R(h)	Progress index P(h)
% SBA assisted deliveries (1998-2002)	1			
95% Confidence Interval	-			
Rate difference, D(h)	-0.349	1		
95% Confidence Interval	[-0.644 to 0.035]	-		
Rate ratio, R(h)	-0.738*	0.832*	1	
95% Confidence Interval	[-0.873 to -0.497]	[0.660 to 0.921]	-	
Progress index, P(h)	-0.148	0.968*	0.715*	1
95% Confidence Interval	[-0.500 to 0.245]	[0.929 to 0.985]	[0.460 to 0.861]	-

Note: Rank correlations based on rankings of progress assessment indicators presented in Table 1.

* Represents significance at 5% level. The confidence intervals reported for Spearman's rank correlation are based on Fisher's transformation.

Finally, the association between the base level of the indicator and the progress assessment methods is examined through the Spearman rank correlation coefficients. As shown in Table 3, rate ratios and rate differentials share a significantly negative association with the base level values (significant at 5 per cent and 10 per cent level, respectively). However, the progress index is independent of the base level, as it values progress only on the basis of both absolute improvements and base levels of the phenomenon. Further, it is discerned that rate differential, rate ratio, and progress index share a significant and positive association with each other, though the confidence intervals around these rank correlations inform that the strength of the association is rather weak between the progress index and rate ratios. This information is also depicted in Figure 4, which plots the base level coverage of skilled health personnel on the x-axis and values of alternative progress assessment indicators on the y-axis. The slope of the fitted line in case rate ratios and rate differentials is found to be significantly negative (at 5 per cent level) whereas the slope of the fitted line for progress index values is statistically no different from zero. However, it may be cautioned that these inferences are applicable for this application only, as such observed association may vary across situations, though the underlying level-related weighting structure remains valid. Also, as a limitation, it must be acknowledged that these methods for progress assessments are not conceived as a measure of aid effectiveness or cost effectiveness of interventions. In fact, for understanding relative effectiveness, these proportions have to be converted into absolute numbers, to arrive at progress per unit of effort, where the latter could be expressed in terms of dollar or population or some other similar input variable.

Figure 4 Association between progress assessment indicators and base level percentage of SHP assisted deliveries



Note: The values of rate differential and rate ratios reported in Table 2 are divided by 100 for a re-scaled presentation along with the progress index value.

5 DISCUSSION AND CONCLUSION

The experience of the international development community with the MDGs has brought out several cross-cutting concerns that will significantly influence goal setting after 2015. For instance, it is expected that global environmental concerns could feature prominently in the post-2015 developmental agenda, alongside other fundamental objectives of poverty reduction and health improvement. Similarly, it is expected that equity issues would receive major attention after 2015, as the MDGs' lack of focus on equity issues has been identified as their most serious shortcoming (Waage et al. 2010). However, it is equally important to argue for a systematic extension of the global objectives at national and subnational levels, as well as for improved conception of developmental targets and indicators, to rectify the definitional and operational inconsistencies associated with MDG indicators (Easterly 2009; Saith 2006; Vandemoortele and Delamonica 2010). This paper derives its motivation from this elementary concern, and aims to highlight the intricacies involved in progress assessments when the base level of a given developmental indicator varies across countries. By means of an illustration, attention is drawn towards the dismal performance of developing regions in improving the proportion of births attended by skilled health personnel over the past two decades.

As such, progress assessment of various MDG indicators continues to be an integral part of policy review and analysis, but is important that such assessments explicitly discuss the desired nature of improvements (absolute or percentage changes) and the underlying social valuation of progress (Easterly 2009). From this perspective, a focus on level-sensitive assessment assumes particular relevance, because commonly used methods (such as rate differentials and rate ratios) often share a negative association with the base level of the indicator, and consequently disregard equivalent progress occurring from a higher base level. Statistical concerns notwithstanding, there is increasing recognition that level-sensitive progress assessments, which provide higher weights for an improvement at a higher level, could proxy the non-linear dynamics of progress at different levels (Fukuda-Parr et al. 2013; Osório 2008;Prennushi et al. 2002; Sen 1981; Dasgupta 1990; Kakwani 1993). In this regard, we further substantiate the need for engaging with level-sensitive indicators. In particular, it is argued that at higher levels, the marginal social cost for further improvement increases disproportionately and, hence, investments that primarily enhance equity through universal coverage should be appreciated in progress assessments (Waage et al. 2010).

We also list a set of desirable properties to review some of the progress assessment indicators suggested in the literature. Specifically, we emphasise that any progress assessment indicator should necessarily qualify the requirements of ratio-based and differential-based level sensitivity. The former condition requires that when two regions show equal proportional improvements, the region with the higher base level should be ranked ahead of the region with the lower base level. Similarly, the latter condition necessitates that in the event of equal absolute improvement, the region with the lower base level should be ranked below the region with the higher base level. The review suggests that most indicators satisfy the conditions of normalisation and monotonocity, but that no single indicator satisfies all the desirable properties (additivity, translation invariance, and ratio- and differential-based level sensitivity). Hence, we also discuss an alternative progress assessment indicator, presented in Subramanian (2008a), which satisfies all these desirable properties. This progress index effectively integrates the level sensitivity concerns by integrating weights for both absolute and relative improvements. Nevertheless, there is scope for developing a progress assessment index that also satisfies sub-group decomposability, another desirable condition.

Following this review, we present an application of these methods, with the intent to stress the dismal focus on the proportion of births attended by skilled health care personnel across developing regions in general and in LDCs in particular. While restricting attention only to inter-temporal comparison, it is observed that sub-Saharan Africa has witnessed near stagnation in the past two decades in the proportion of deliveries attended by skilled health personnel (42 per cent in 1990 and 45 per cent in 2010). The South Asia region had the lowest coverage (30 per cent) during 1990, but the health systems in the region appear functional, as the past two decades have witnessed some improvement in coverage (49 per cent in 2010). But, because of a heavy population share, the magnitude of the problem in South Asia is expected to be as challenging as those encountered by sub-Saharan Africa. Besides, excluding South Asia and Latin America, no other developing region has shown any acceleration in progress after 2000. Given the relevance of this indicator for MDGs 4 and 5, this finding indicates that interventions for skilled health care at births have remained a rather neglected aspect under the MDGs.

We also evaluate the performance of LDCs, but without any reference to any target or benchmark, such as the MDGs. The focus of such inter-country comparisons is to unravel the plight of poorer countries, and to draw the attention of the international development community towards inter-country disparities within LDCs in the selected health system indicator. For analytical purposes, the country-level data for LDCs was accessed from the official UN website for MDG indicators. Information on the proportion of births attended by skilled health personnel for 1998–2002 and 2008–2012 is analysed. We notice huge inter-country disparities in coverage, which apparently ranges from 10 per cent in Ethiopia to 95 per cent in Maldives (a range of 85 per cent across selected 27 LDC countries). Analysis using rate differential, rate ratio, and progress index further demonstrates how level sensitivity considerations can influence our inferences on the progress and performance of countries. For any given level of progress, these three methods present differing weighting mechanisms. The rate ratio provides a higher weight to equivalent improvements occurring at lower base levels; consequently, Nepal, which has progressed from a base level of 11 per cent in

1998–2002 to 36 per cent in 2008–2012, is ranked ahead of all other LDCs. The rate difference provides uniform weights to progress irrespective of the base level; accordingly, Bhutan, with the highest absolute progress (24 per cent in 1998–2002 to 65 per cent in 2008–2012) is regarded as the best progressing country. The progress index provides higher weights to improvements occurring at higher levels and therefore identifies Cambodia (32 per cent in 1998–2002 to 71 per cent in 2008–2012) as the best performing LDC during 2000s. Through graphical presentation and Spearman rank correlations, it is also illustrated how rate ratios and rate differentials share a negative association with the base level of the indicator, but how the progress index is fairly uncorrelated.

In concluding, we reiterate the problem associated with some of the common indicators of progress assessment, and argue for the adoption of level-sensitive progress assessment methodologies in post-2015 goal setting. This requires a systematic approach for arriving at regional and sub-group specific interpretations of broader developmental goals, which is also expected to resolve some of the definitional and operational inconsistencies associated with existing developmental targets and indicators. Since the post-2015 developmental agenda—increasingly referred to as the Sustainable Development Goals (SDG)—is expected to have a shared focus on economic, environmental, and social goals (Sachs 2012), it is expected that some of the neglected indicators and associations will receive due consideration. Specifically, we have highlighted that the persistently lower proportion of deliveries attended by skilled health personnel is a major concern; and, given the dismal progress of sub-Saharan Africa and South Asia (mainly LDCs), this indicator can have an overwhelming relevance for reducing maternal and neonatal mortality in the developing world.

Appendix

Proof for properties of P(h)

Normalisation

The index $P(h)$ attains a maximum value of $P(h) = 1$ when $h(t_2) = b_h$ and $h(t_1) = a_h$ (i.e., $\Delta h = b_h - a_h$) and would assume a minimum value of $P(h) = -1$ when $h(t_2) = a_h$ and $h(t_1) = b_h$(i.e., $\Delta h = a_h - b_h$). Given the general expression of $P(h)$, it is obvious that $P(h)$ can be zero if: f(.) = 0 or $\Delta h = 0$. The latter case is desirable and justified because it corresponds to the situation of no progress or deterioration of the health variable between two time points. Assuming that there exists a combination of $f(a_h, b_h, h) = 0$, it has to be ensured that f(.) $\neq$ 0. In addition, a further restriction is also imposed on f(.) such that it adopts the sign of Δh and leads to the above interpretation of the progress index. Clearly, the normalisation condition is satisfied if and only if $f(a_h, b_h, h) > 0$.

Monotonocity

From inspection, it is obvious that since Δh is part of the numerator in $P(h)$, any increment in the Δh will increase the value of the index. Also, an increase in Δh implies that the denominator in $P(h)$ would shrink and further increase the value of $P(h)$.

Minimality

Since the weighting function, $f(a_h, b_h, h(t_1), h(t_2))$, is always positive, it implies that $P(h) > 0$ whenever $\Delta h = h(t_2) - h(t_1) > 0$. *Maximality*: $P(h) = 1$ if and only if $\Delta h = h(t_2) - h(t_1) = b_h$.

Translation invariance

Let $\beta > 0$ be the coefficient for positive proportional transformation:

$P(\beta h) = \{2(\beta b_h - \beta a_h)/\{[2(\beta b_h - \beta a_h) - \beta h(t_2))] * [2(\beta b_h - \beta a_h) - \beta h(t_1)]\}\}* \Delta\beta h$

$P(\beta h) = \{2\beta(b_h - a_h)/\{\beta[2(b_h - a_h) - h(t_2)] * \beta[2(b_h - a_h) - h(t_1)]\}\}* \Delta\beta h$

$P(\beta h) = \{2\beta^2(b_h - a_h)/\{\beta^2[2(b_h - a_h) - h(t_2)] * [2(b_h - a_h) - h(t_1)]\}\}* \Delta h$

$P(\beta h) = \{2(b_h - a_h)/\{[2(b_h - a_h) - h(t_2)] * [2(b_h - a_h) - h(t_1)]\}\}* \Delta h$

$P(\beta h) = P(h)$

Difference-based level sensitivity

Consider two different contexts X and Y such that $\Delta h_X = h^X(t_2) - h^X(t_1) = \Delta h_Y = h^Y(t_2) - h^Y(t_1)$. Also, $h^X(t_1) > h^Y(t_1)$. These conditions imply that the numerator in the progress index, $P(h)$, for both the contexts will be same. However, given that $h^X(t_1) > h^Y(t_1)$, the denominator of the progress index for context X will be smaller than context Y. Hence, it follows that $P_X(h) > P_Y(h)$.

Ratio-based level sensitivity: Consider two different contexts X and Y such that $h^X(t_2)/h^X(t_1) = h^Y(t_2)/h^Y(t_1)$. Also, $h^X(t_1) > h^Y(t_1)$. These conditions inform that the numerator in the respective progress index $P_X(h)$ and $P_Y(h)$ will be greater for context X. Also, it can be discerned that the denominator of the progress index for context X will be smaller than context Y. Hence, it follows that $P_X(h) > P_Y(h)$.

Additivity

For ease of exposition, we demonstrate the proof with standardised health variables and two sub-periods.

Let

$\Delta h^A = h(t_2) - h(t_1)$;

$\Delta h^B = h(t_3) - h(t_2)$;

$\Delta h^Z = h(t_3) - h(t_1)$, then;

$P(h^A) + P(h^B) = [2(h(t_2)- h(t_1))]/[(2- h(t_1))* (2- h(t_2))] + [2(h(t_3)- h(t_2))]/[(2- h(t_3))* (2- h(t_2))]$

$P(h^A) + P(h^B) = [2/(2- h(t_2))]*\{[(h(t_2)- h(t_1))/(2- h(t_1))] - [(h(t_3)- h(t_2))/(2- h(t_3))]\}$

On simplification and rearranging, we get;

$P(h^A) + P(h^B) = [2/(2- h(t_2))]*\{[(h(t_3)- h(t_1))(2- h(t_2))]/[(2- h(t_1))/(2- h(t_3))]\}$

$P(h^A) + P(h^B) = [2(h(t_3)- h(t_1))]/[(2- h(t_3))* (2- h(t_1))]$.

$P(h^A) + P(h^B) = P(h^Z)$.

REFERENCES

Addison, T., G Mavrotas and M McGillivray (2005) Aid to Africa: An unfinished agenda, *Journal of International Development*, 17(8): 989–1001.

Atkinson, A B (1970) On the measurement of inequality *Journal of Economic Theory.* 2: 244–63.

Dasgupta, P (1990) Well-being and the extent of its realization in poor countries. *Economic Journal* (Supplement) 100.

Easterly, W., (2009) How the Millennium Development Goals are unfair to Africa. *World Development* 37(1): 26–35.

Farr, W., (1875) Letter to The Registrar-General on the Mortality in the Registration Districts of England during the Years 1861-70. In Humphreys, N. A., (Ed) Vital Statistics: A memorial volume of selections from the reports and writings of William Farr. London, The Sanitary Institute of Great Britain, 1885: 166–205, published in the Bulletin of World Health Organization, 2000, 78 (1).

Fukuda-Parr, Sakiko, J Greenstein and D Stewart (2013) How should MDG success and failure be judged: Faster progress or achieving the targets? *World Development* 41: 19–30.

Gaudin, S and A Yazbeck (2006) Immunization in India 1993–1999: Wealth, gender, and regional inequalities revisited. *Social Science & Medicine*, 62(3): 694–706.

Hailu, D and R Tsukada (2011) Achieving the Millennium Development Goals: A measure of progress. Working Paper 78, International Policy Centre for Inclusive Growth.

Houweling, T.A.J., A E Kunst, M Huisman, J P Mackenbach (2007) Using relative and absolute measures for monitoring health inequalities: experiences from cross-national analyses on maternal and child health. *International Journal for Equity in Health*. 6 (15): 1–9.

Joe W (2014) Intersectional inequalities in immunization in India 1992-93 to 2005-06: A progress assessment, *Health Policy and Planning*, forthcoming.

Kakwani N (1993) Performance in living standards: an international comparison. *Journal of Development Economics* 41 (2): 307–36.

Mishra, U S and S Subramanian (2006) On measuring group differentials displayed by socio-economic indicators. *Applied Economics Letters* 13 (8): 519–21.

Moser F, C Frost and D A Leon (2007) Comparing health inequalities across time and place–rate ratios and rate differences lead to different conclusions: analysis of cross-sectional data from 22 countries 1991–2001. *International Journal of Epidemiology* (36): 1285–291

Nathan, H S K and S Mishra (2013) Group differential for attainment and failure indicator. *Journal of International Development*, in press (DOI: 10.1002/jid.2898).

Osorio, R G (2008) Alternatives for projecting MDGs indicators. *Technical Paper* 2. Brasilia, International Policy Centre for Inclusive Growth.

Pande, R and A Yazbeck (2003) What's in a country average? Wealth, gender, and regional inequalities in immunization in India. Social Science & Medicine 57(11), 2075–88.

Prennushi, G, G Rubio and K Subbarao (2002) Monitoring and evaluation. In: Klugman, J. (Ed), *A Sourcebook for Poverty Reduction Strategies.* Washington DC, World Bank.

Sachs J D (2012) From Millennium Development Goals to Sustainable Development Goals, *Lancet* 379: 2206–11

Saith, A (2006) From universal values to Millennium Development Goals: Lost in translation', *Development and Change* 37 (6), 1167–99.

Sen, A K (1981) Public action and the quality of life in developing countries. *Oxford Bulletin of Economics and Statistics* 43: 287–319.

Subramanian, S (2004) Measuring literacy: Some extensions of the Basu–Foster framework. *Journal of Development Economics* 73 (1), 453–63.

Subramanian, S (2008a) Externality and literacy: A note. *Journal of Development Studies* 44 (6): 839–48.

Subramanian, S (2008b) On a 'level-sensitive' headcount ratio: Revisiting Shorrocks' Poverty Index. *Social Indicators Research* 88 (3), 477–82.

Tabatabai, H (2007) MDG targets: Misunderstood or misconceived? *IPC-IG One Pager* 33. Brasilia, International Policy Centre for Inclusive Growth.

United Nations (2013) The Millennium Development Goals Report 2013. New York.

United Nations (2012) *The Millennium Development Goals Report 2012*. New York.

Vandemoortele, Jan and E Delamonica. (2010) Taking the MDGs beyond 2015: Hasten slowly. *IDS Bulletin* 41 (1): 60–69.

Vandemoortele, J (2009) The MDG Conundrum: Meeting the targets without missing the point, *Development Policy Review* 27 (4): 355–71

Victoria C G et al. (2000) Explaining trends in inequities: Evidence from Brazilian child health studies. *Lancet* 356: 1093–98

Waage J et al. (2010) The Millennium Development Goals: A cross-sectoral analysis and principles for goal setting after 2015. *Lancet* 376: 991–1023.

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