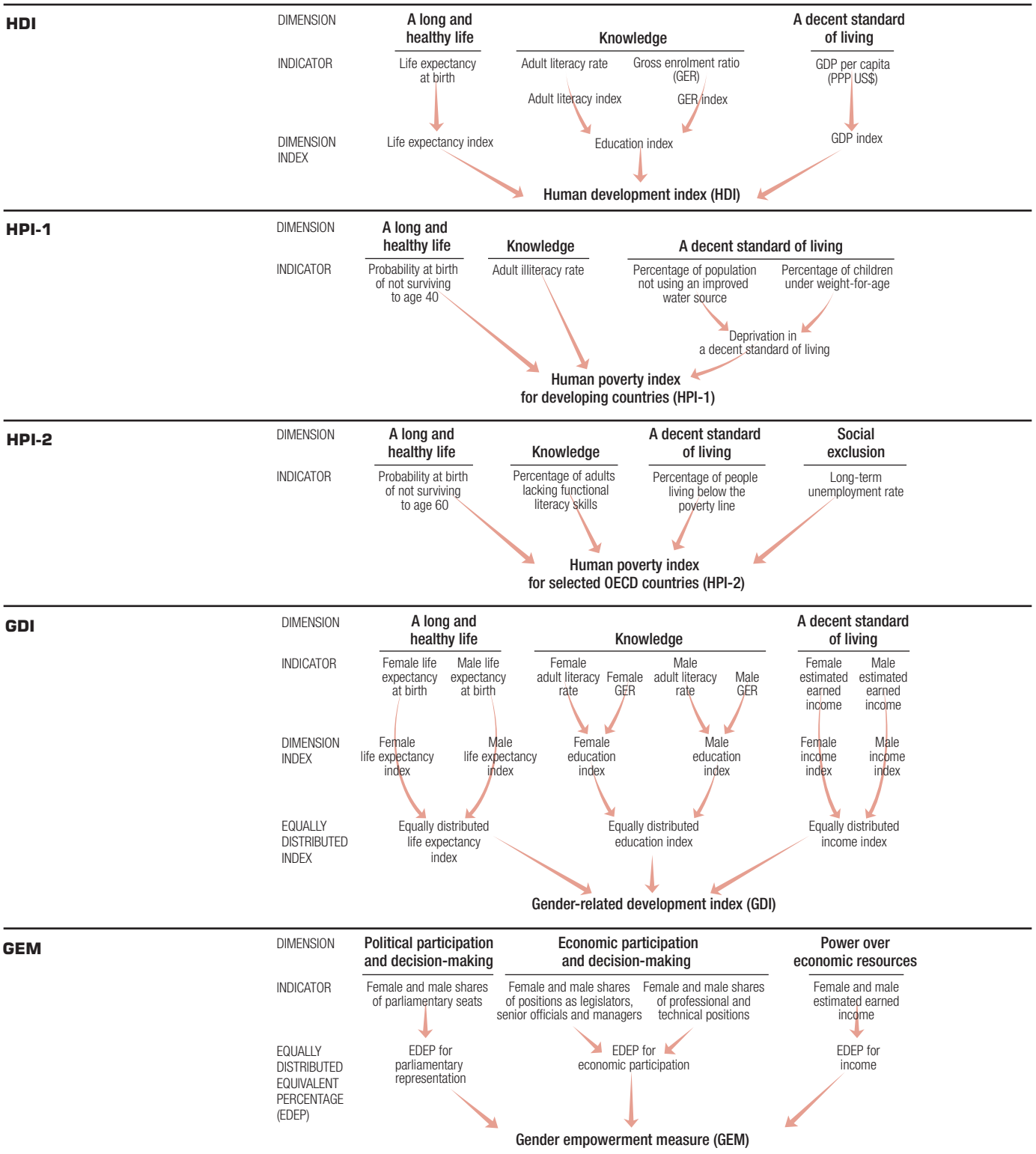
TECHNICAL NOTE 1

Calculating the human development indices

The diagrams here summarize how the five human development indices used in the *Human Development Report* are constructed, highlighting both their similarities and their differences. The text on the following pages provides a detailed explanation.

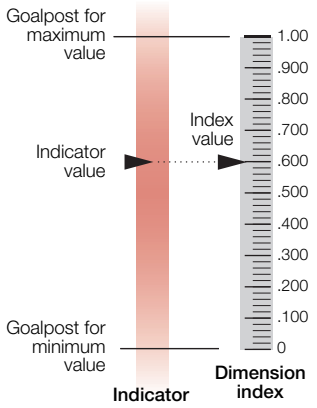


The human development index (HDI)

The HDI is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth.
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight).
- A decent standard of living, as measured by GDP per capita in purchasing power parity (PPP) terms in US dollars.

Before the HDI itself is calculated, an index needs to be created for each of these dimensions. To calculate these indices—the life expectancy, education and GDP indices—minimum and maximum values (goalposts) are chosen for each underlying indicator.



Performance in each dimension is expressed as a value between 0 and 1 by applying the following general formula:

$$\text{Dimension index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

The HDI is then calculated as a simple average of the dimension indices. The box on the right illustrates the calculation of the HDI for a sample country.

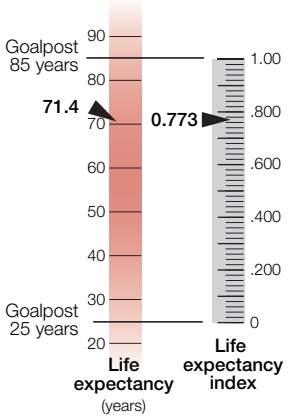
Goalposts for calculating the HDI

Indicator	Maximum value	Minimum value
Life expectancy at birth (years)	85	25
Adult literacy rate (%)*	100	0
Combined gross enrolment ratio (%)	100	0
GDP per capita (PPP US$)	40,000	100

* The goalpost for calculating adult literacy implies the maximum literacy rate is 100%. In practice, the HDI is calculated using an upper bound of 99%.

Calculating the HDI

This illustration of the calculation of the HDI uses data for Turkey.



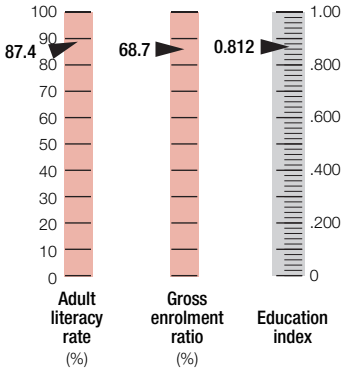
1. Calculating the life expectancy index

The life expectancy index measures the relative achievement of a country in life expectancy at birth. For Turkey, with a life expectancy of 71.4 years in 2005, the life expectancy index is 0.773.

$$\text{Life expectancy index} = \frac{71.4 - 25}{85 - 25} = \mathbf{0.773}$$

2. Calculating the education index

The education index measures a country's relative achievement in both adult literacy and combined primary, secondary and tertiary gross enrolment. First, an index for adult literacy and one for combined gross enrolment are calculated. Then these two indices are combined to create the education index, with two-thirds weight given to adult literacy and one-third weight to combined gross enrolment. For Turkey, with an adult literacy rate of 87.4% in 2005 and a combined gross enrolment ratio of 68.7% in 2005, the education index is 0.812.



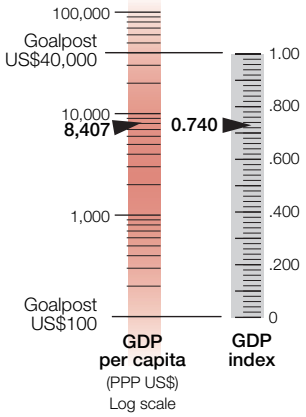
$$\text{Adult literacy index} = \frac{87.4 - 0}{100 - 0} = 0.874$$

$$\text{Gross enrolment index} = \frac{68.7 - 0}{100 - 0} = 0.687$$

$$\text{Education index} = 2/3\ (\text{adult literacy index}) + 1/3\ (\text{gross enrolment index})$$
$$= 2/3\ (0.874) + 1/3\ (0.687) = \mathbf{0.812}$$

3. Calculating the GDP index

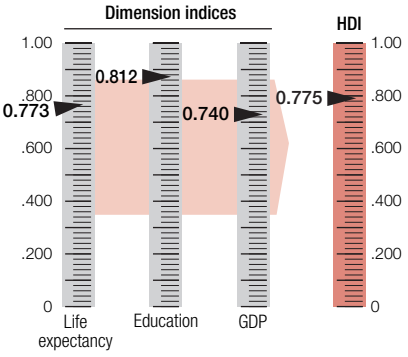
The GDP index is calculated using adjusted GDP per capita (PPP US$). In the HDI income serves as a surrogate for all the dimensions of human development not reflected in a long and healthy life and in knowledge. Income is adjusted because achieving a respectable level of human development does not require unlimited income. Accordingly, the logarithm of income is used. For Turkey, with a GDP per capita of 8,407 (PPP US$) in 2005, the GDP index is 0.740.



$$\text{GDP index} = \frac{\log(8{,}407) - \log(100)}{\log(40{,}000) - \log(100)} = \mathbf{0.740}$$

4. Calculating the HDI

Once the dimension indices have been calculated, determining the HDI is straightforward. It is a simple average of the three dimension indices.



$$\text{HDI} = 1/3\ (\text{life expectancy index}) + 1/3\ (\text{education index}) + 1/3\ (\text{GDP index})$$
$$= 1/3\ (0.773) + 1/3\ (0.812) + 1/3\ (0.740) = \mathbf{0.775}$$

The human poverty index for developing countries (HPI-1)

While the HDI measures average achievement, the HPI-1 measures *deprivations* in the three basic dimensions of human development captured in the HDI:

- A long and healthy life—vulnerability to death at a relatively early age, as measured by the probability at birth of not surviving to age 40.
- Knowledge—exclusion from the world of reading and communications, as measured by the adult illiteracy rate.
- A decent standard of living—lack of access to overall economic provisioning, as measured by the unweighted average of two indicators, the percentage of the population not using an improved water source and the percentage of children under weight-for-age.

Calculating the HPI-1 is more straightforward than calculating the HDI. The indicators used to measure the deprivations are already normalized between 0 and 100 (because they are expressed as percentages), so there is no need to create dimension indices as for the HDI.

The human poverty index for selected OECD countries (HPI-2)

The HPI-2 measures deprivations in the same dimensions as the HPI-1 and also captures social exclusion. Thus it reflects deprivations in four dimensions:

- A long and healthy life—vulnerability to death at a relatively early age, as measured by the probability at birth of not surviving to age 60.
- Knowledge—exclusion from the world of reading and communications, as measured by the percentage of adults (ages 16–65) lacking functional literacy skills.
- A decent standard of living—as measured by the percentage of people living below the income poverty line (50% of the median adjusted household disposable income).
- Social exclusion—as measured by the rate of long-term unemployment (12 months or more).

Calculating the HPI-1

1. Measuring deprivation in a decent standard of living

An unweighted average of two indicators is used to measure deprivation in a decent standard of living.

$$\text{Unweighted average} = 1/2\ (\text{population not using an improved water source}) + 1/2\ (\text{children under weight-for-age})$$

A sample calculation: Bolivia

Percentage of population not using an improved water source = 15%

Percentage of children under weight-for-age = 8%

$$\text{Unweighted average} = 1/2\ (15) + 1/2\ (8) = 11.3\%$$

2. Calculating the HPI-1

The formula used to calculate the HPI-1 is as follows:

$$\text{HPI-1} = [1/3\ (P_1^{\alpha} + P_2^{\alpha} + P_3^{\alpha})]^{1/\alpha}$$

Where:

P_1 = Probability at birth of not surviving to age 40 (times 100)

P_2 = Adult illiteracy rate

P_3 = Unweighted average of population not using an improved water source and children under weight-for-age

$\alpha = 3$

A sample calculation: Bolivia

$P_1 = 15.5\%$

$P_2 = 13.3\%$

$P_3 = 11.3\%$

$$\text{HPI-1} = [1/3\ (15.5^3 + 13.3^3 + 11.3^3)]^{1/3} = \mathbf{13.6}$$

Calculating the HPI-2

The formula used to calculate the HPI-2 is as follows:

$$\text{HPI-2} = [1/4\ (P_1^{\alpha} + P_2^{\alpha} + P_3^{\alpha} + P_4^{\alpha})]^{1/\alpha}$$

Where:

P_1 = Probability at birth of not surviving to age 60 (times 100)

P_2 = Percentage of adults lacking functional literacy skills

P_3 = Percentage of population below income poverty line (50% of median adjusted household disposable income)

P_4 = Rate of long-term unemployment (lasting 12 months or more)

$\alpha = 3$

A sample calculation: Canada

$P_1 = 8.1\%$

$P_2 = 14.6\%$

$P_3 = 11.4\%$

$P_4 = 0.5\%$

$$\text{HPI-2} = [1/4\ (8.1^3 + 14.6^3 + 11.4^3 + 0.5^3)]^{1/3} = \mathbf{10.9}$$

Why $\alpha = 3$ in calculating the HPI-1 and HPI-2

The value of α has an important impact on the value of the HPI. If $\alpha = 1$, the HPI is the average of its dimensions. As α rises, greater weight is given to the dimension in which there is the most deprivation. Thus as α increases towards infinity, the HPI will tend towards the value of the dimension in which deprivation is greatest (for Bolivia, the example used to calculate the HPI-1, would be 15.5, equal to the probability at birth of not surviving to age 40).

In this Report the value 3 is used to give additional but not overwhelming weight to areas of more acute deprivation. For a detailed analysis of the HPI's mathematical formulation, see Sudhir Anand and Amartya Sen's "Concepts of Human Development and Poverty: A Multidimensional Perspective" and the technical note in *Human Development Report 1997* (see the list of selected readings at the end of this technical note).

The gender-related development index (GDI)

While the HDI measures average achievement, the GDI adjusts the average achievement to reflect the *inequalities* between men and women in the following dimensions:

- A long and healthy life, as measured by life expectancy at birth.
- Knowledge, as measured by the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio.
- A decent standard of living, as measured by estimated earned income (PPP US$).

The calculation of the GDI involves three steps. First, female and male indices in each dimension are calculated according to this general formula:

$$\text{Dimension index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

Second, the female and male indices in each dimension are combined in a way that penalizes differences in achievement between men and women. The resulting index, referred to as the equally distributed index, is calculated according to this general formula:

$$\text{Equally distributed index} = \{[\text{female population share} \times (\text{female index}^{1-\epsilon})] + [\text{male population share} \times (\text{male index}^{1-\epsilon})]\}^{1/1-\epsilon}$$

ϵ measures the aversion to inequality. In the GDI $\epsilon = 2$. Thus the general equation becomes:

$$\text{Equally distributed index} = \{[\text{female population share} \times (\text{female index}^{-1})] + [\text{male population share} \times (\text{male index}^{-1})]\}^{-1}$$

which gives the harmonic mean of the female and male indices.

Third, the GDI is calculated by combining the three equally distributed indices in an unweighted average.

Goalposts for calculating the GDI

Indicator	Maximum value	Minimum value
Female life expectancy at birth (years)	87.5	27.5
Male life expectancy at birth (years)	82.5	22.5
Adult literacy rate (%)	100	0
Combined gross enrolment ratio (%)	100	0
Estimated earned income (PPP US$)	40,000	100

Note: The maximum and minimum values (goalposts) for life expectancy are 5 years higher for women to take into account their longer life expectancy. To preserve the relationship between female and male values of each indicator, scaled values are computed and used in place of figures where either the female or male value exceeds the threshold (in the case of Adult Literacy a practical threshold value of 99% is used). The scaling is achieved by multiplying the female and male values by the practical threshold value divided by the maximum reported value for either females or males.

Calculating the GDI

This illustration of the calculation of the GDI uses data for Botswana.

1. Calculating the equally distributed life expectancy index

The first step is to calculate separate indices for female and male achievements in life expectancy, using the general formula for dimension indices.

FEMALE
Life expectancy: 48.4 years

$$\text{Life expectancy index} = \frac{48.4 - 27.5}{87.5 - 27.5} = 0.348$$

MALE
Life expectancy: 47.6 years

$$\text{Life expectancy index} = \frac{47.6 - 22.5}{82.5 - 22.5} = 0.419$$

Next, the female and male indices are combined to create the equally distributed life expectancy index, using the general formula for equally distributed indices.

FEMALE
Population share: 0.504
Life expectancy index: 0.348

MALE
Population share: 0.496
Life expectancy index: 0.419

$$\text{Equally distributed life expectancy index} = \{[0.504\ (0.348^{-1})] + [0.496\ (0.419^{-1})]\}^{-1} = \mathbf{0.380}$$

2. Calculating the equally distributed education index

First, indices for the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio are calculated separately for females and males. Calculating these indices is straightforward, since the indicators used are already normalized between 0 and 100.

FEMALE
Adult literacy rate: 81.8%
Adult literacy index: 0.818
Gross enrolment ratio: 70.1%
Gross enrolment index: 0.701

MALE
Adult literacy rate: 80.4%
Adult literacy index: 0.804
Gross enrolment ratio: 69.0%
Gross enrolment index: 0.690

Second, the education index, which gives two-thirds weight to the adult literacy index and one-third weight to the gross enrolment index, is computed separately for females and males.

$$\text{Education index} = 2/3\ (\text{adult literacy index}) + 1/3\ (\text{gross enrolment index})$$

$$\text{Female education index} = 2/3\ (0.818) + 1/3\ (0.701) = 0.779$$

$$\text{Male education index} = 2/3\ (0.804) + 1/3\ (0.690) = 0.766$$

Finally, the female and male education indices are combined to create the equally distributed education index.

FEMALE
Population share: 0.504
Education index: 0.779

MALE
Population share: 0.496
Education index: 0.766

$$\text{Equally distributed education index} = \{[0.504\ (0.779^{-1})] + [0.496\ (0.766^{-1})]\}^{-1} = \mathbf{0.773}$$

3. Calculating the equally distributed income index

First, female and male earned income (PPP US$) are estimated (for details on this calculation, see the addendum to this technical note). Then the income index is calculated for each gender. As with the HDI, income is adjusted by taking the logarithm of estimated earned income (PPP US$):

$$\text{Income index} = \frac{\log(\text{actual value}) - \log(\text{minimum value})}{\log(\text{maximum value}) - \log(\text{minimum value})}$$

FEMALE
Estimated earned income (PPP US$): 5,913

$$\text{Income index} = \frac{\log(5{,}913) - \log(100)}{\log(40{,}000) - \log(100)} = 0.681$$

MALE
Estimated earned income (PPP US$): 19,094

$$\text{Income index} = \frac{\log(19{,}094) - \log(100)}{\log(40{,}000) - \log(100)} = 0.877$$

Calculating the GDI continues on next page

Calculating the GDI (continued)

Second, the female and male income indices are combined to create the equally distributed income index :

FEMALE	MALE
Population share: 0.504	Population share: 0.496
Income index: 0.681	Income index: 0.877

$$\text{Equally distributed income index} = \{[0.504\ (0.681^{-1})] + [0.496\ (0.877^{-1})]\}^{-1} = \mathbf{0.766}$$

4. Calculating the GDI

Calculating the GDI is straightforward. It is simply the unweighted average of the three component indices—the equally distributed life expectancy index, the equally distributed education index and the equally distributed income index.

$$\text{GDI} = 1/3\ (\text{life expectancy index}) + 1/3\ (\text{education index}) + 1/3\ (\text{income index})$$
$$= 1/3\ (0.380) + 1/3\ (0.773) + 1/3\ (0.766) = \mathbf{0.639}$$

Why $\epsilon = 2$ in calculating the GDI

The value of ϵ is the size of the penalty for gender inequality. The larger the value, the more heavily a society is penalized for having inequalities.

If $\epsilon = 0$, gender inequality is not penalized (in this case the GDI would have the same value as the HDI). As ϵ increases towards infinity, more and more weight is given to the lesser-achieving group.

The value 2 is used in calculating the GDI (as well as the GEM). This value places a moderate penalty on gender inequality in achievement.

For a detailed analysis of the GDI's mathematical formulation, see Sudhir Anand and Amartya Sen's "Gender Inequality in Human Development: Theories and Measurement," Kalpana Bardhan and Stephan Klasen's "UNDP's Gender-Related Indices: A Critical Review" and the technical notes in *Human Development Report 1995* and *Human Development Report 1999* (see the list of selected readings at the end of this technical note).

The gender empowerment measure (GEM)

Focusing on women's opportunities rather than their capabilities, the GEM captures gender inequality in three key areas:

- Political participation and decision-making power, as measured by women's and men's percentage shares of parliamentary seats.
- Economic participation and decision-making power, as measured by two indicators—women's and men's percentage shares of positions as legislators, senior officials and managers and women's and men's percentage shares of professional and technical positions.
- Power over economic resources, as measured by women's and men's estimated earned income (PPP US$).

For each of these three dimensions, an equally distributed equivalent percentage (EDEP) is calculated, as a population-weighted average, according to the following general formula:

$$\text{EDEP} = = \{[\text{female population share} \times (\text{female index}^{1-\epsilon})] + [\text{male population share} \times (\text{male index}^{1-\epsilon})]\}^{1/1-\epsilon}$$

ϵ measures the aversion to inequality. In the GEM (as in the GDI) $\epsilon = 2$, which places a moderate penalty on inequality. The formula is thus:

$$\text{EDEP} = \{[\text{female population share} \times (\text{female index}^{-1})] + [\text{male population share} \times (\text{male index}^{-1})]\}^{-1}$$

For political and economic participation and decision-making, the EDEP is then indexed by dividing it by 50. The rationale for this indexation is that in an ideal society, with equal empowerment of the sexes, the GEM variables would equal 50%—that is, women's share would equal men's share for each variable.

Where a male or female index value is zero, the EDEP according to the above formula is not defined. However, the limit of EDEP, when the index tends towards zero, is zero. Accordingly, in these cases the value of the EDEP is set to zero.

Finally, the GEM is calculated as a simple average of the three indexed EDEPs.

Calculating the GEM

This illustration of the calculation of the GEM uses data for the Russian Federation.

1. Calculating the EDEP for parliamentary representation

The EDEP for parliamentary representation measures the relative empowerment of women in terms of their political participation. The EDEP is calculated using the female and male shares of the population and female and male percentage shares of parliamentary seats according to the general formula.

FEMALE	MALE
Population share: 0.536	Population share: 0.464
Parliamentary share: 8.0%	Parliamentary share: 92.0%

$$\text{EDEP for parliamentary representation} = \{[0.536 \times (8.0^{-1})] + [0.464 \times (92.0^{-1})]\}^{-1} = 13.88$$

Then this initial EDEP is indexed to an ideal value of 50%.

$$\text{Indexed EDEP for parliamentary representation} = \frac{13.88}{50} = \mathbf{0.278}$$

2. Calculating the EDEP for economic participation

Using the general formula, an EDEP is calculated for women's and men's percentage shares of positions as legislators, senior officials and managers, and another for women's and men's percentage shares of professional and technical positions. The simple average of the two measures gives the EDEP for economic participation.

FEMALE	MALE
Population share: 0.536	Population share: 0.464
Percentage share of positions as legislators, senior officials and managers: 39.0%	Percentage share of positions as legislators, senior officials and managers: 61.0%
Percentage share of professional and technical positions: 64.7%	Percentage share of professional and technical positions: 35.3%

$$\text{EDEP for positions as legislators, senior officials and managers} = \{[0.536 \times (39.0^{-1})] + [0.464 \times (61.0^{-1})]\}^{-1} = 46.85$$

$$\text{Indexed EDEP for positions as legislators, senior officials and managers} = \frac{46.85}{50} = 0.937$$

$$\text{EDEP for professional and technical positions} = \{[0.536 \times (64.7\text{-}^{1})] + [0.464 \times (35.3\text{-}^{1})]\}\text{-}^{1} = 46.67$$

$$\text{Indexed EDEP for professional and technical positions} = \frac{46.67}{50} = 0.933$$

The two indexed EDEPs are averaged to create the EDEP for economic participation:

$$\text{EDEP for economic participation} = \frac{0.937 + 0.933}{2} = \mathbf{0.935}$$

3. Calculating the EDEP for income

Earned income (PPP US$) is estimated for women and men separately and then indexed to the scaled goalposts as was done for the GDI (for details, see the addendum to this technical note.). For the GEM, however, the income index is based on unadjusted values, not the logarithm of estimated earned income.

FEMALE	MALE
Population share: 0.536	Population share: 0.464
Estimated earned income (PPP US$): 8,476	Estimated earned income (PPP US$): 13,581
$\text{Income index} = \frac{8{,}476 - 100}{40{,}000 - 100} = 0.210$	$\text{Income index} = \frac{13{,}581 - 100}{40{,}000 - 100} = 0.338$

The female and male indices are then combined to create the equally distributed index:

$$\text{EDEP for income} = \{[0.536 \times (0.210^{-1})] + [0.464 \times (0.338^{-1})]\}^{-1} = \mathbf{0.255}$$

4. Calculating the GEM

Once the EDEP has been calculated for the three dimensions of the GEM, determining the GEM is straightforward. It is a simple average of the three EDEP indices.

$$\text{GEM} = \frac{0.278 + 0.935 + 0.255}{3} = \mathbf{0.489}$$

TECHNICAL NOTE 1 ADDENDUM

Female and male earned income

Despite the importance of having gender-disaggregated data on income, direct measures are unavailable. For this Report crude estimates of female and male earned income have therefore been derived.

Income can be seen in two ways: as a resource for consumption and as earnings by individuals. The use measure is difficult to disaggregate between men and women because they share resources within a family unit. By contrast, earnings are separable because different members of a family tend to have separate earned incomes.

The income measure used in the GDI and the GEM indicates a person's capacity to earn income. It is used in the GDI to capture the disparities between men and women in command over resources and in the GEM to capture women's economic independence. (For conceptual and methodological issues related to this approach, see Sudhir, Anand and Amartya Sen's "Gender Inequality in Human Development" and, in *Human Development Report 1995*, chapter 3 and *Technical notes 1 and 2*; see the list of selected readings at the end of this technical note.)

Female and male earned income (PPP US$) are estimated using the following data:

- Ratio of the female nonagricultural wage to the male nonagricultural wage.
- Male and female shares of the economically active population.
- Total female and male population.
- GDP per capita (PPP US$).

Key

W_f/W_m = ratio of female nonagricultural wage to male nonagricultural wage
EA_f = female share of economically active population
EA_m = male share of economically active population
S_f = female share of wage bill
Y = total GDP (PPP US$)
N_f = total female population
N_m = total male population
Y_f = estimated female earned income (PPP US$)
Y_m = estimated male earned income (PPP US$)

Note

Because of rounding, calculations carried out by hand may yield results that differ from those printed in the technical notes and indicator tables.

Estimating female and male earned income

This illustration of the estimation of female and male earned income uses 2005 data for Sweden.

1. Calculating total GDP (PPP US$)
Total GDP (PPP US$) is calculated by multiplying the total population by GDP per capita (PPP US$).

Total population: 9,024 (thousand)
GDP per capita (PPP US$): 32,525
Total GDP (PPP US$) = 9,024 (32,525) = 293,510,764 (thousand)

2. Calculating the female share of the wage bill
Because data on wages in rural areas and in the informal sector are rare, the Report has used nonagricultural wages and assumed that the ratio of female wages to male wages in the nonagricultural sector applies to the rest of the economy. The female share of the wage bill is calculated using the ratio of the female nonagricultural wage to the male nonagricultural wage and the female and male percentage shares of the economically active population. Where data on the wage ratio are not available, a value of 75% is used.

Ratio of female to male nonagricultural wage $(W_f/W_m) = 0.907$
Female percentage share of economically active population $(EA_f) = 47.4\%$
Male percentage share of economically active population $(EA_m) = 52.6\%$

$$\text{Female share of wage bill } (S_f) = \frac{W_f/W_m\,(EA_f)}{[W_f/W_m\,(EA_f)] + EA_m} = \frac{0.907\,(47.4)}{[0.907\,(47.4) + 52.6} = 0.450$$

3. Calculating female and male earned income (PPP US$)
An assumption has to be made that the female share of the wage bill is equal to the female share of GDP.

Female share of wage bill $(S_f) = 0.450$
Total GDP (PPP US$) $(Y) = 293,510,764$ (thousand)
Female population $(N_f) = 4,546$ (thousand)

$$\text{Estimated female earned income (PPP US\$) } (Y_f) = \frac{S_f\,(Y)}{N_f} = \frac{0.450\,(293,510,764)}{4,546} = 29,044$$

Male population $(N_m) = 4,478$ (thousand)

$$\text{Estimated male earned income (PPP US\$) } (Y_m) = \frac{Y - S_f\,(Y)}{N_m} = \frac{293,510,764 - [0.450\,(293,510,764)]}{4,478} = 36,059$$

Selected readings

Anand, Sudhir, and Amartya Sen. 1994. "Human Development Index: Methodology and Measurement". Occasional Paper 12, United Nations Development Programme, Human Development Report Office, New York. *(HDI)*

——, 1995, "Gender Inequality in Human Development Theories and Measurement." Occasional Paper 19, United Nations Development Programme, Human Development Report Office, New York. *(GDI, GEM)*

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Bardhan, Kalpana, and Stephan Klasen, 1999. "UNDP's Gender-Related Indices. A Critical Review." *World Development* 27 (6): 985–1010 *(GDI, GEM)*

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