ILO ESTIMATES AND PROJECTIONS OF THE ECONOMICALLY ACTIVE POPULATION: 1990-2020 (SIXTH EDITION)

Methodological description

October 2011

Contents

Preface

The 6th Edition of the estimates and projections of the economically active population EAPEP Database is the result of a joint collaboration between the ILO Department of Statistics and the ILO Employment Trends Unit.

In this edition, the Employment Trends Unit and the Department of Statistics had the joint responsibility for developing the historical estimates (1990-2010), whilst the Department of Statistics had primary responsibility for developing the projections.

For this edition, enhanced methodologies have been developed in order to improve the EAPEP labour force estimates and projections. There are several important changes in this edition as compared to the previous one.

Firstly, the statistical basis has been increased (in other words, the proportion of imputed values has been reduced). In addition, the historical estimates (1990-2010) are now accompanied by detailed metadata for each data point. The metadata include several fields regarding the source of collected data, the type of adjustments made to harmonise them (when needed) and the type of imputation method used to fill missing data.

Concerning the projection exercise, the projections are now based on a wider range of models than in the previous edition. Notably, they allow the capture of the impact of the latest economic (and still on-going) crisis on the labour force participation for concerned countries. Finally, in this edition the ILO uses projections made by National Statistical Offices (NSOs), provided that these have been published recently. This concerns around twelve countries.

The resulting models and methodologies will be the basis for subsequent updates of the EAPEP Database by the Department of Statistics and the Employment Trends Unit.

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Also, a special thank you to Stefanie Garry for editorial work.

1. Introduction

The ILO programme on estimates and projections of the economically active population is part of a larger international effort on demographic estimates and projections to which several UN agencies contribute. Estimates and projections of the total population and its components by sex and age group are produced by the UN Population Division, and employed populations by the ILO, the agricultural population by FAO and the school attending population by UNESCO.

The main objective of the ILO programme is to provide member states, international agencies and the public at large with the most comprehensive, detailed and comparable estimates and projections of the economically active population in the world and its main geographical regions. The first edition was published by the ILO Department of Statistics in 1971 (covering 168 countries and territories, with reference period 1950-1985)[1]; the second edition in 1977 (with 154 countries and territories and reference period 1975-2000)[2]; the third edition in 1986 (with 156 countries and territories and reference period 1985-2025)[3]; the fourth edition in 1996 (with 178 countries and territories and reference period 1950-2010)[4]; the fifth edition in 2007 (with 191 countries and reference period 1980-2020) with two subsequent updates (in August 2008 and December 2009)[5].

The present sixth edition covers 191 countries and territories. The reference period for the estimates is 1990-2010 and for the projections is 2011-2020. For countries with historical data prior to 1990 (but after 1979), estimates concerning the period prior to 1990 are also provided.

The basic data are single-year labour force participation rates by sex and age groups, of which ten groups are defined by five-year age intervals (15-19, 20-24, ..., 60-64) and the last age group is defined as 65 years and above. The data are available at the ILO main website for labour statistics: http://laborsta.ilo.org.

The purpose of the present note is to describe the main elements of the estimation and projection methodologies adopted for the sixth edition. For this edition, enhanced methodologies have been developed in order to improve the EAPEP labour force estimates and projections. Firstly, the statistical basis has been increased (in other words, the proportion of imputed values has been reduced). In addition, the historical estimates (1990-2010) are now accompanied by detailed metadata for each data point regarding the source of collected data, the type of adjustments made to harmonise them (when needed) and the type of imputation method used to fill missing data. Concerning the projection exercise, the projections are now based on a wider range of models than in the previous edition. Notably, they allow the capture of the impact of the latest economic (and still on-going) crisis on the labour force participation for concerned countries. Finally, in this edition the ILO uses projections made by National Statistical Offices (NSOs), provided that these have been published recently. The following chart (figure 1) depicts the main steps involved.

[1] ILO, Labour force projections, 1965-85 (1st edition, Geneva 1971).

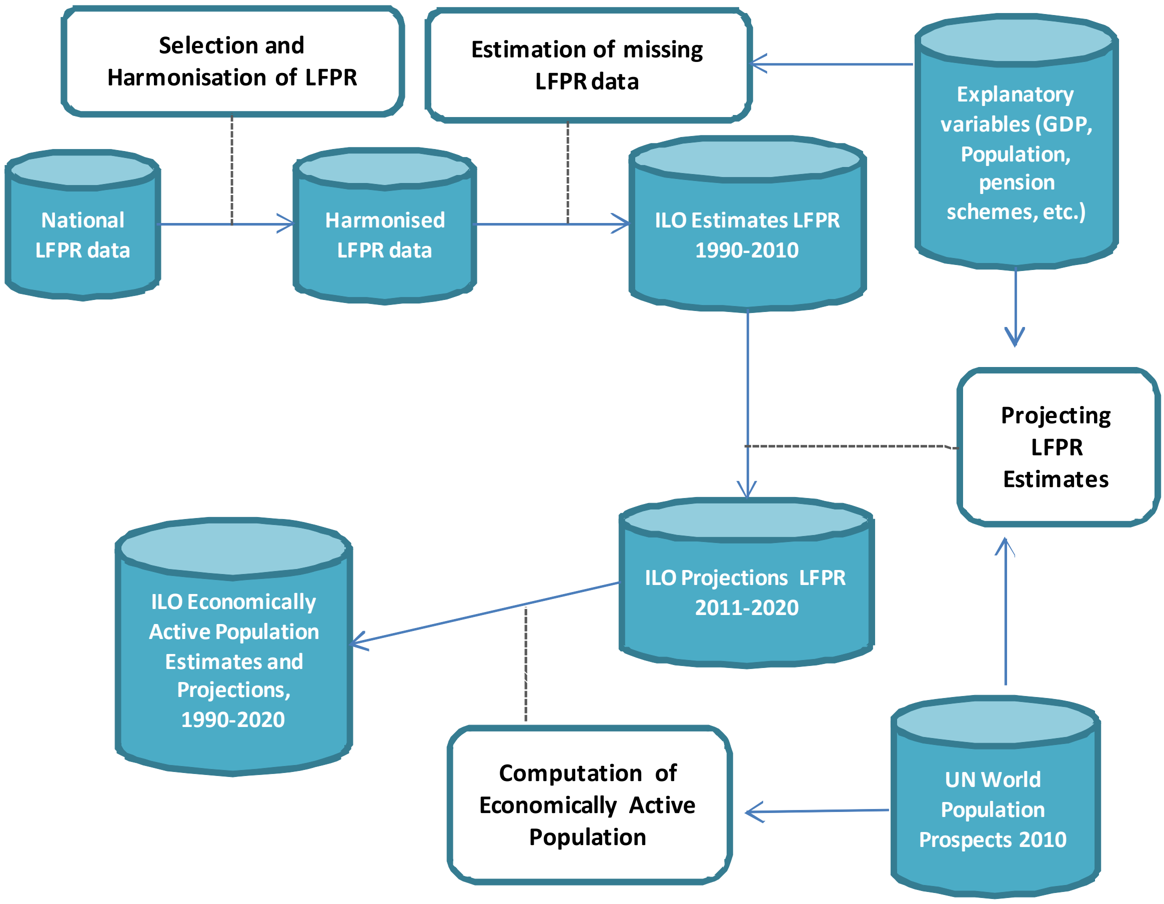
[2] ILO, Labour force projections, 1950-2010 (2nd edition, Geneva 1976).

[3] ILO, Economically Active Population: Estimates and projections, 1950-2025 (3rd edition, Geneva 1986).

[4] ILO, Economically Active Population Estimates and projections, 1950-2010 (4th edition, Geneva 1996).

[5] ILO, Estimates and Projections of the Economically Active Population, 1980-2020 (5th edition, Geneva 2007, Update August 2008, Update December 2009).

Figure 1. ILO Estimates and Projections of the Economically Active Population 1990-2020 (Sixth edition)



The determinants of labour force participation are described in section 2. The underlying national labour force data used for producing harmonised single-year ILO country estimates of labour force participation rates (LFPR) by sex and standard age groups are described in section 3. That section also includes the description of the statistical treatment of missing values and the estimation models for countries for which no or limited data were available. The projection methodology is described in section 4. The different strengths and limitations of the present methodology are presented in section 5, as well as proposed directions for future work. Finally, section 6 illustrates the different outputs that are available from the website.

2. Determinants of labour force participation

2.a. Microeconomic perspective

According to the neoclassical theory of labour supply, individual labour supply is a trade-off between the consumption of goods and leisure. The number of hours that an individual is ready to work is a function of labour and non-labour income, as well as other individual characteristics (preferences, level of studies achieved, maternity and parental duties, etc.). In the empirical literature on labour supply the following equation is frequently presented[6]:

$$\ln h = a_w \ln w + a_R \ln R + x\theta + \varepsilon$$

The variable *h* is the hours worked by a given individual at hourly wage *w*, *R* is a measure of non-labour income, *x* is a vector (1,n) describing the *n* characteristics of the individual (control variables), and ε is random term reflecting the individual heterogeneity.

The above equation is only valid for hourly wages that are above the "reservation wage". The later is a theoretical wage defined as the minimum wage you need in order to participate in the market. In other words, an individual participates in the labour market if the market wage exceeds his or her reservation wage.

An individual's reservation wage may change over time depending on a number of factors, like changes in the individual's overall wealth, changes in marital status or living arrangements, length of unemployment, and health and disability issues. An individual might also set a higher reservation wage when considering an offer of an unpleasant or undesirable job than when considering a type of job the individual likes.

The neoclassical theory can be extended at the community or household level. In other words, this individual decision can be extended to the household or community level (e.g., agragian structures where land is held in common).

2.b. Macroeconomic perspective

At the macroeconomic level, what is observed are average aggregated participation rates for the whole population or subgroups of it (male, female, prime age, youth, etc.). These data are derived from labour force or household surveys or from population censuses. The variable "participation rate" is of dichotomous nature: either you participate or you do not. The average number of hours the population is ready to work is not captured by macro-economic data.

The determinants of the participation rate can be broken down into structural or long-term factors, cyclical factors and accidental factors.

Structural factors include policy and legal determinants (e.g., flexibility of working-time arrangements, taxation, family support, retirement schemes, apprenticeships, work permits, unemployment benefits, minimum wage) as well as other determinants (e.g., demographic and cultural factors, level of education, technological progress, availability of transportation).

Some key findings regarding female labour force participation rates (LFPR)[7]:

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[6] For a comprehensive survey, see Blundell and MaCurdy (1999).

[7] For more details see Jaumotte (2003).

- In countries where working-time arrangements are more flexible, there is a higher LFPR of female workers than in other countries.
- Taxation of second earners (relative to single earners) usually has a negative impact on female LFPR.
- Childcare subsidies and paid parental leave usually have a positive impact on female LFPR.
- In countries where the proportion of unmarried women is higher, there is usually a higher female LFPR than in other countries.
- Cultural factors such as strong family ties or religion have a strong impact on LFPR for some subgroups of the population. For example, in many countries, religious or social norms may discourage women from undertaking economic activities.

These structural factors are the main drivers of the long-term patterns in the data. Changes in policy and legal determinants (e.g., changes in retirement and pre-retirements schemes) can result in important shifts in participation rates from one year to another.

Cyclical factors refer to the overall economic and labour market conditions that influence the LFPR. In other words, labour demand has an impact on labour supply. In times of strong slowdown or recession, two effects on the participation rates, with opposite signs, are referred to in the literature: the “discouraged worker effect” and the "additional worker effect”.

The "discouraged worker effect" is very important for younger people. In times of discouraging labour market conditions, the length of studies usually increases. The LFPR of younger age groups is more sensitive to severe downturns where there is easier access to post-secondary education.

The "additional worker effect" applies more to female or older workers who enter (or re-enter) the labour market in order to compensate for the job losses and decreased earnings of some members of the family or the community.

Also according to a recent OECD study (see OECD 2010), in times of severe downturns, the changes in the LFPR of older persons depend on financial incentives to continue working as compared to taking retirement.

Lastly, there are **accidental factors** such as wars, strikes and natural disasters that also affect LFPR, usually in a temporary manner.

3. Estimation model 1990-2010: data and methodology

3.a. Introduction

The EAPEP database is a collection of country-reported and ILO estimated labour force participation rates. The database is a complete panel, that is, it is a cross-sectional time series database with no missing values. A key objective in the construction of the database is to generate a set of comparable labour force participation rates across both countries and time. With this in mind, the first step in the production of the historical portion of the 6th Edition of the EAPEP database is to carefully scrutinize existing country-reported labour force participation rates and to select only those observations deemed sufficiently comparable. Two subsequent adjustments are done to the national LFPR data in order to increase the statistical basis (in other words, to decrease the proportion of imputed values); that is, harmonization of LFPR data by age bands and adjustment based on urban data (see Annexes 3 and 4 for a detailed description of these adjustments). In the second step, a weighted least squares panel model was developed to produce estimates of labour force participation rates for those countries and years in which no country-reported, cross-country comparable data currently exist.

This section contains two main parts. The first part provides an overview of the criteria used to select the baseline national labour force participation rate (LFPR) data that serve as the key input into the ILO's Economically Active Population Estimates and Projections (EAPEP) 6th Edition database. This section includes a discussion of non-comparability issues that exist in the available national LFPR data and concludes with a description of the LFPR data coverage, after taking into account the various selection criteria. The second part describes the econometric model developed for the treatment of missing LFPR values, both in countries that report in some but not all of the years in question, as well as for those countries for which no data are currently available.

3.b. Data selection criteria and coverage

Non-comparability issues

In order to generate a set of sufficiently comparable labour force participation rates across both countries and time, it is necessary to identify and address the various sources of non-comparability. This section draws heavily on the labour force participation data comparability discussion in the Key Indicators of the Labour Market (KILM), 7th Edition (Geneva, ILO 2011). The main sources of non-comparability of labour force participation rates are as follows:

Type of source – country-reported labour force participation rates are derived from several types of sources including labour force surveys, population censuses, establishment surveys, insurance records or official government estimates. Data taken from different types of sources are often not comparable.

Age group coverage – non-comparability also arises from differences in the age groupings used in measuring the labour force. While the standard age-groupings used in the EAPEP Database are 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64 and 65+, some countries report non-standard age groupings, which can adversely affect broad comparisons. For example, some countries have adopted non-standard lower or upper age limits for inclusion in the labour force, with a cut-off point at 14 or 16 years for the lower limit and 65 or 70 years for the upper limit.

Geographic coverage – some country-reported labour force participation rates correspond to a specific geographic region, area or territory such as "urban areas". Geographically-limited data are not comparable across countries.

Others – Non-comparability can also arise from the inclusion or non-inclusion of military conscripts; variations in national definitions of the economically active population, particularly with regard to the statistical treatment of "contributing family workers" and the "unemployed, not looking for work"; and differences in survey reference periods.

Data selection criteria

Taking these issues into account, a set of criteria was established upon which nationally-reported labour force participation rates would be selected for or eliminated from the input file for the EAPEP dataset.[8] There are three criteria described hereafter.

Selection criterion 1 (type of source)

Data must be derived from either a labour force or household survey or a population census. Population census data are included only if no labour force or household survey data exist for a given country. Labour force surveys are the most comprehensive source for internationally comparable labour force data. National labour force surveys are typically very similar across countries, and the data derived from these surveys are generally much more comparable than data obtained from other sources. Consequently, a strict preference was given to labour force survey data in the selection process. Yet, many developing countries without adequate resources to carry out a labour force survey do report LFPR estimates based on population censuses. Due the need to balance the competing goals of data comparability and data coverage, some population census-based labour force participation rates were included. However, a strict preference was given to labour force survey-based data, with population census-derived estimates only included for countries in which no labour force survey-based participation data exist. Data derived from official government estimates in principle were not included in the dataset as the methodology for producing official estimates can differ significantly across countries and over time, leading to non-comparability. However, bearing in mind that as large a statistical basis as possible is preferable to a fully imputed series, the available official government estimates are kept for 6 countries.[9]

Selection criterion 2 (age coverage)

Data broken down by age groups are included in the initial input. For example, when the labour force participation rate refers to the total working age population, this observation is not included. Ideally, the reported rate corresponds to the 11 standardized age-groups (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64 and 65+). For the countries with non-standardised age-groups, two types of harmonisation has been applied; harmonising the lower and upper age limit and harmonising data from large age bands to the above standard 5-year age bands. Detailed descriptions of these harmonisations can be found in Annex 3.

Selection criterion 3 (geographical coverage)

Regarding the geographical selection criteria, data corresponding to national (i.e. not geographically limited) labour force participation rates or data adjusted to represent national participation rates are included. Labour force participation rates corresponding to only urban or only rural areas are not comparable across countries. This criterion was necessary due to the large differences that often exist between rural and urban

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[8] All labour force participation data in the EAPEP input file were selected from the ILO Key Indicators of the Labour Market (KILM) 7th Edition Database (Geneva, 2011), http://www.ilo.org/kilm. The main sources of data in the KILM include the ILO Labour Statistics (Laborsta), http://laborsta.ilo.org; the Organization for Economic Development and Cooperation (OECD) Labour Force Statistics Database, http://www.oecd.org; the Statistical Office of the European Communities (EUROSTAT) European Labour Force Survey (EU LFS) online database (http://epp.eurostat.ec.europa.eu); ILO Regional Office for Latin America and the Caribbean Labour Analysis and Information System (SIAL) Project (http://www.oitsial.org.pa/) and the ILO Labour Market Indicators Library (LMIL), http://www.ilo.org/trends, which contains data collected by the online and printed reports of National Statistical Offices (NSO).

[9] These countries are Cameroon, Haiti, Senegal, Sudan, Togo and Ukraine.

labour markets. For four countries in Latin America, the labour force participation rates corresponding to urban areas only were adjusted (see Annex 4).

Resulting input data file

Together, these criteria determined the data content of the final input file, which was utilized in the subsequent econometric estimation process (described below). Table 1 provides response rates and total observations by age-group and year. These rates represent the share of total potential (or maximum) observations for which real, cross-country comparable data (after harmonisation adjustments) exist.

Table 1. Response rates by year, both sexes combined

Year	Proportion of potential observations[a]	Number of observations
1980	0.13	541
1981	0.12	508
1982	0.14	572
1983	0.22	927
1984	0.17	711
1985	0.22	921
1986	0.21	894
1987	0.20	835
1988	0.24	1'023
1989	0.27	1'153
1990	0.26	1'104
1991	0.28	1'161
1992	0.26	1'112
1993	0.29	1'198
1994	0.30	1'248
1995	0.34	1'415
1996	0.31	1'323
1997	0.32	1'343
1998	0.34	1'426
1999	0.35	1'483
2000	0.37	1'552
2001	0.36	1'510
2002	0.36	1'528
2003	0.39	1'628
2004	0.42	1'753
2005	0.45	1'870
2006	0.43	1'802
2007	0.41	1'724
2008	0.45	1'872
2009	0.41	1'704
2010	0.32	1'328
Total	0.30	39'169

[a] The potential number of observations for each year is 4'202 data points (11 age-groups x 191 countries x 2 sexes). Hence, the total potential number of observations which covers the time period 1980 to 2010 is 130'262 data points.

In total, comparable data are available for 39'169 out of a possible 130'262 observations, or approximately 30 per cent of the total. It is important to note that while the percentage of real observations is rather low, 174 out of 191 countries (91 per cent) reported labour force participation rates in at least one year during the 1980 to 2010 reference period. [10] Thus, some information on LFPR is known about the vast majority of the countries in the sample.

There is very little difference among the 11 age-groups with respect to data availability. This is primarily due to the fact that countries that report LFPR in a given year tend to report for all age groups. On the other hand, there is a clear variation in response by year. In particular, coverage has tended to improve over time, as the lowest coverage occurred in the early 1980s. While the overall response rate is approximately 30 per cent, as will be shown in the next section, response rates vary substantially among the different regions of the world.

3.c. Missing value estimation procedure

Overview

This section describes the basic missing value estimation model developed to produce the EAPEP historical database. The model was developed by the ILO Employment Trends Unit as part of its ongoing responsibility for the development and analysis of world and regional aggregates of key labour market indicators including labour force, employment, unemployment, employment status, employment by sector and working poverty, among others.[11] The present methodology contains four steps. First, in order to ensure realistic estimates of labour force participation rates, a logistic transformation is applied to the input data file. Second, a simple interpolation technique is utilized to expand the baseline data in countries that report labour force participation rates in some years. Next, the problem of non-response bias (systematic differences between countries that report data in some years and countries that do not report data in any year) is addressed and a solution is developed to correct for this bias. Finally, the weighted least squares estimation model, which produces the actual country-level LFPR estimates, is explained in detail. Each of these steps is described below.

Step 1: Logistic transformation

The first step in the estimation process is to transform all labour force participation rates included in the input file. This step is necessary since using simple linear estimation techniques to estimate labour force participation rates can yield implausible results (for instance labour force participation rates of more than 100 per cent). Therefore, in order to avoid out of range predictions, the final input set of labour force participation rates is transformed logistically in the following manner prior to the estimation procedure:

$$Y_{it} = \ln\left(\frac{y_{it}}{1-y_{it}}\right) \quad (1)$$

where y_{it} is the observed labour force participation rate by sex and age in country *i* and year *t*. This transformation ensures within-range predictions, and applying the inverse transformation produces the original labour force participation rates. The specific choice of a logistic function in the present context was chosen following Crespi (2004).

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[10] The 17 countries or territories for which no comparable information on labour force participation rate by sex and age exist to our knowledge are: Afghanistan, Angola, Channel Islands, Eritrea, Guinea, Guinea-Bissau, Democratic People's Republic of Korea, Libyan Arab Jamahiriya, Mauritania, Myanmar, Solomon Islands, Somalia, Swaziland, Turkmenistan, United States Virgin Islands, Uzbekistan, and Western Sahara.

[11] A series of background papers on the Trends Unit's work related to world and regional aggregates including methodological documents on the relevant econometric models can be found at http://www.ilo.org/trends.

Step 2: Country-level interpolation

The second step in the estimation model is to fill in, through linear interpolation, the set of available information from countries that report in some, but not all of the years in question. In many reporting countries, some gaps in the data do exist. For instance, a country will report labour force participation rates in 1990 and 1995, but not for the years in between. In these cases, a simple linear interpolation routine is applied, in which LFPR estimates are produced using equation 2.

$$Y_{it} = \frac{Y_{i1} - Y_{i0}}{t_1 - t_0}(t - t_0) + Y_{i0} \qquad (2)$$

In this equation, Y_{i1} is the logistically transformed labour force participation rate in year t_1, which corresponds to the closest reporting year in country *i* following year *t*. Y_{i0} is the logistically transformed labour force participation rate in year t_0, which is the closest reporting year in country *i* preceding year *t*. Accordingly, Y_{i1} is bounded at the most recent overall reporting year for country *i*, while Y_{i0} is bounded at the earliest reporting year for country *i*.

This procedure increases the number of observations upon which the econometric estimation of labour force participation rates in reporting and non-reporting countries is based. It relies on the assumption that structural factors are predominant as compared to the cyclical and accidental ones.

Table 2. Response rates by estimation group

Estimation group	Number of observations	Number of observations, post-interpolation	Proportion of potential observations[a] (%)	Proportion of potential observations[a] (%), post-interpolation
Developed Europe (22 countries)	12'054	12'122	80.3	80.8
Developed Non-Europe (9 countries)	5'362	5'584	87.4	91.0
CEE and CIS (27countries)	5'632	9'392	30.6	51.0
East and South-East Asia (22 countries)	2'800	5'540	18.7	36.9
South Asia (9 countries)	1'143	3'120	18.6	50.8
Central America and the Caribbean (25 countries)	4'952	9'704	29.0	56.9
South America (10 countries)	3'088	4'646	45.3	68.1
Middle East and North Africa (19 countries)	2'069	6'077	16.0	46.9
Sub-Saharan Africa (48 countries)	2'069	8'351	6.3	25.5
Total (191 countries)	39'169	64'536	30.1	49.5

[a] The potential number of observations for each region is calculated by 11 age-groups x number of countries x 2 sexes x (2010-1980+1).

The increase in observations resulting from the linear interpolation procedure is provided in Table 2. This table also provides a picture of the large variation in data availability among the different geographic/economic estimation groups. In total, the number of observations increased from 39'169 to 64'536 – that is, from 30 per cent to 50 per cent of the total potential observations. The lowest data coverage is in sub-Saharan Africa, where the post-interpolation coverage is 25.5 per cent. Post-interpolation coverage reaches 80.8 per cent in the Developed Europe region and 91 per cent in the Developed Non-Europe region. The resulting database represents the final set of harmonized real and estimated labour force participation rates upon which the multivariate weighted estimation model was carried out as described below.

Step 3: Calculation of response-probabilistic weights

Out of 191 countries in the EAPEP database, 17 do not have any reported comparable labour force participation rates over the 1980-2010 period (see footnote 10). This raises the potential problem of non-response bias. That is, if labour force participation rates in countries that do not report data tend to differ significantly from participation rates in countries that do report, basic econometric estimation techniques will result in biased estimates of labour force participation rates for the non-reporting countries, as the sample upon which the estimates are based does not sufficiently represent the underlying heterogeneity of the population.[12]

The identification problem at hand is essentially whether data in the EAPEP database are missing completely at random (MCAR), missing at random (MAR) or not missing at random (NMAR).[13] If the data are MCAR, non-response is ignorable and multiple imputation techniques such as those inspired by Heckman (1979) should be sufficient for dealing with missing data. This is the special case in which the probability of reporting depends neither on observed nor unobserved variables – in the present context this would mean that reporting and non-reporting countries are essentially "similar" in both their observable and unobservable characteristics as they relate to labour force participation rates. If the data are MAR, the probability of sample selection depends only on observable characteristics. That is, it is known that reporting countries are different from non-reporting countries, but the factors that determine whether countries report data are identifiable. In this case, econometric methods incorporating a weighting scheme, in which weights are set as the inverse probability of selection (or inverse propensity score), is one common solution for correcting for sample selection bias. Finally, if the data are NMAR, there is a selection problem related to unobservable differences in characteristics among reporters and non-reporters, and methodological options are limited. In cases where data are NMAR, it is desirable to render the MAR assumption plausible by identifying covariates that impact response probability (Little and Hyonggin, 2003).

Given the important methodological implications of the non-response type, it is useful to examine characteristics of reporting and non-reporting countries in order to determine the type of non-response present in the EAPEP database. Table 3 confirms significant differences between reporting and non-reporting countries in the sample.

[12] For more information, see Crespi (2004) and Horowitz and Manski (1998).

[13] See Little and Hyonggin (2003) and Nicoletti (2002).

Table 3. Per-capita GDP and population size of reporting and non-reporting countries

	Reporters (174 countries)	Non-reporters (17 countries)
Mean per-capita GDP, 2010(2005 International $)	13'460	5'262
Median per-capita GDP, 2010 (2005 International $)	7'694	2'379
Mean population, 2010 (millions)	38.4	11.4
Median population, 2010 (millions)	7.6	5.3

Sources: World Bank, World Development Indicators Database 2011; UN, World Population Prospects 2010 Revision Database.

The table shows that reporting countries have considerably higher per capita GDP and larger populations than non-reporting countries. In the context of the EAPEP database, it is important to note that countries with low per-capita GDP also tend to exhibit higher than average labour force participation rates, particularly among women, youth and older individuals. This outcome is borne mainly due to the fact that the poor often have few assets other than their labour upon which to survive. Thus, basic economic necessity often drives the poor to work in higher proportions than the non-poor. As economies develop, many individuals (particularly women) can afford to work less, youth can attend school for longer periods, and consequently, overall participation rates in developing economies moving into the middle stages of development tend to decline.[14]

It appears that factors exist that co-determine the likelihood of countries to report labour force participation rates in the EAPEP input dataset and the actual labour force participation rates themselves. The missing data do not appear to be MCAR. Due to the existence of data (such as per-capita GDP and population size) that exist for both responding and non-responding countries and that are related to response likelihood, it should be possible to render the MAR assumption plausible and thus to correct for the problem of non-response bias.[15] This correction can be made while using the fixed-effects panel estimation methods described below, by applying "balancing weights" to the sample of reporting countries. The remainder of the present discussion describes this weighting routine in greater detail.

The basic methodology utilized to render the data MAR and to correct for sample selection bias contains two steps. The first step is to estimate each country's probability of reporting labour force participation rates. In the EAPEP input dataset, per-capita GDP, population size, year dummy variables and membership in the Highly Indebted Poor Country (HIPC) Initiative represent the set of independent variables used to estimate response probability.[16]

Following Crespi (2004) and Horowitz and Manski (1998), we characterize each country in the EAPEP input dataset by a vector (y_{it}, x_{it}, w_{it}, r_{it}), where y is the outcome of interest (the logistically transformed labour force participation rate), x is a set of covariates that determine the value of the outcome and w is a set of covariates that determine the probability of the outcome being reported. Finally, r is a binary variable indicating response or non-response as follows:

$$r_{it} = \begin{cases} 1 & \text{if } i \text{ reports} \\ 0 & \text{if } i \text{ does not report} \end{cases} \qquad (3)$$

Equation 4 indicates that there is a linear function whereby the likelihood of reporting labour force participation rates is a function of the set of covariates:

[14] See ILO, KILM 7th Edition, (Geneva, ILO, 2011) and Standing, G. *Labour Force Participation and Development* (Geneva, ILO, 1978).

[15] Indeed, according to Little and Hyonggin (2003), the most useful variables in this process are those that are predictive of both the missing values (in this case labour force participation rates) and of the missing data indicator. Per-capita GDP is therefore a particularly attractive indicator in the present context.

[16] HIPC membership is utilized as an explanatory variable for response probability due to the fact that HIPC member countries are required to report certain statistics needed to measure progress toward national goals related to the program. As a result, taking all else equal, HIPC countries may be more likely to report labour force participation rates.

$$r_{it}^{*} = w_{it}^{'}\gamma + \varepsilon_{it} \qquad (4)$$

where a country reports if this index value is positive ($r_{it}^{*} > 0$). γ is the set of regression coefficients and ε_{it} is the error term. Assuming a symmetric cumulative distribution function, the probability of reporting labour force participation rates can be written as in equation 5.

$$P_i = F\left(w_{it}^{'}\gamma\right) \qquad (5)$$

The functional form of *F* depends on the assumption made about the error term ε_{it}. As in Crespi (2004), we assume that the cumulative distribution is logistic, as shown in equation 6:

$$F\left(w_{it}^{'}\gamma\right) = \frac{\exp\left(w_{it}^{'}\gamma\right)}{1 + \exp\left(w_{it}^{'}\gamma\right)} \qquad (6)$$

It is necessary to estimate equation 6 through logistic regression, which is carried out by placing each country into one of the 9 estimation groups listed in Table 2. The regressions are carried out for each of the 11 standardized age-groups and for males and females. The results of this procedure provide the predicted response probabilities for each age-group within each country in the EAPEP dataset.

The second step is to calculate country weights based on these regression results and to use the weights to "balance" the sample during the estimation process. The predicted response probabilities calculated in equation 6 are used to compute weights defined as:

$$s_{it}(w) = \frac{P(r_{it} = 1)}{P(r_{it} = 1 \mid w_{it}, \hat{\gamma})} \qquad (7)$$

The weights given by equation 7 are calculated as the ratio of the proportion of non-missing observations in the sample (for each age-group and each year) and the reporting probability estimated in equation 6 of each age-group in each country in each year. By calculating the weights in this way, reporting countries that are more similar to the non-reporting countries (based on characteristics including per-capita GDP, population size and HIPC membership) are given greater weight and thus have a greater influence in estimating labour force participation rates in the non-reporting countries, while reporting countries that are less similar to non-reporting countries are given less weight in the estimation process. As a result, the weighted sample looks more similar to the theoretical population framework than does the simple un-weighted sample of reporting countries.

Step 4: Weighted multivariate estimation

The final step is the estimation process itself. Countries are again divided into the 9 estimation groups listed above, which were chosen on the combined basis of broad economic similarity and geographic proximity.[17] Having generated response-probabilistic weights to correct for sample selection bias, the key issues at hand include 1) the precise model specification and 2) the choice of independent variables for estimating labour force participation.

In terms of model specification, taking into account the database structure and the existence of unobserved heterogeneity among the various countries in the EAPEP input database, the choice was made to use panel data techniques with country fixed effects, with the sample of reporting countries weighted using the $s_{it}(w)$

[17] Schaible (2000) discusses the use of geographic proximity and socio-economic status to define estimation domains for data estimation including for ILO labour force participation rates. See also Schaible and Mahadevan-Vijaya (2002).

to correct for non-response bias.[18] By using fixed effects in this way, the "level" of known labour force participation rates in each reporting country is taken into account when estimating missing values in the reporting country, while the non-reporting countries borrow the fixed effect of a similar reporter country. The similarity is simply based on economic and social factors, such as per capita GDP and general cultural norms. More formally, the following linear model was constructed (and run on the logistically transformed labour force participation rates):

$$Y_{it} = \alpha_i + x_{it}^{'}\beta + e_{it} \qquad (8)$$

where α_i is country-specific fixed effect, χ_{it} is a set of explanatory covariates of the labour force participation rate and e_{it} is the error term. The main set of covariates included is listed in table 4.[19]

Table 4. Independent variables in fixed-effects panel regression

Variable	Source
Per-capita GDP, Per-capita GDP squared Real GDP growth rate, Lagged real GDP growth rate	World Bank, World Development Indicators 2011 and IMF, World Economic Outlook April 2011
Share of population aged 0-14, Share of population aged 15-24, Share of population aged 25-64	United Nations, World Population Prospects 2010 Revision Database

In the context of the EAPEP database, there are two primary considerations in selecting independent variables for estimation purposes. First, the selected variables must be robust correlates of labour force participation, so that the resulting regressions have sufficient explanatory power. Second, in order to maximize the data coverage of the final EAPEP database, the selected independent variables must have sufficient data coverage.

In terms of variables related to economic growth and development, as mentioned above, per-capita GDP is often strongly associated with labour force participation.[20] This, together with the substantial coverage of the indicator made it a prime choice for estimation purposes. However, given that the direction of the relationship between economic development and labour force participation can vary depending on a country's stage of development, the square of this term was also utilized to allow for this type of non-linear relationship.[21] Figure 2 depicts clearly that this relationship varies by both sex and age group. For men and women in the prime-age, there is no relationship, statistically speaking. For both men and women aged 15 to 19 years, and those aged above 55 years, there is a clear U-relationship between per capita GDP and labour force participation rate. Furthermore, annual GDP growth rates were used to incorporate the relationship between participation and the state of the macro-economy.[22] The lag of this term was also included in order to allow for delays between shifts in economic growth and changes in participation.

[18] Crespi (2004) provides a test comparing the bias resulting from different missing value estimation models and finds that the weighted least squares model using fixed-effects provides the smallest relative bias when estimating unemployment rates.

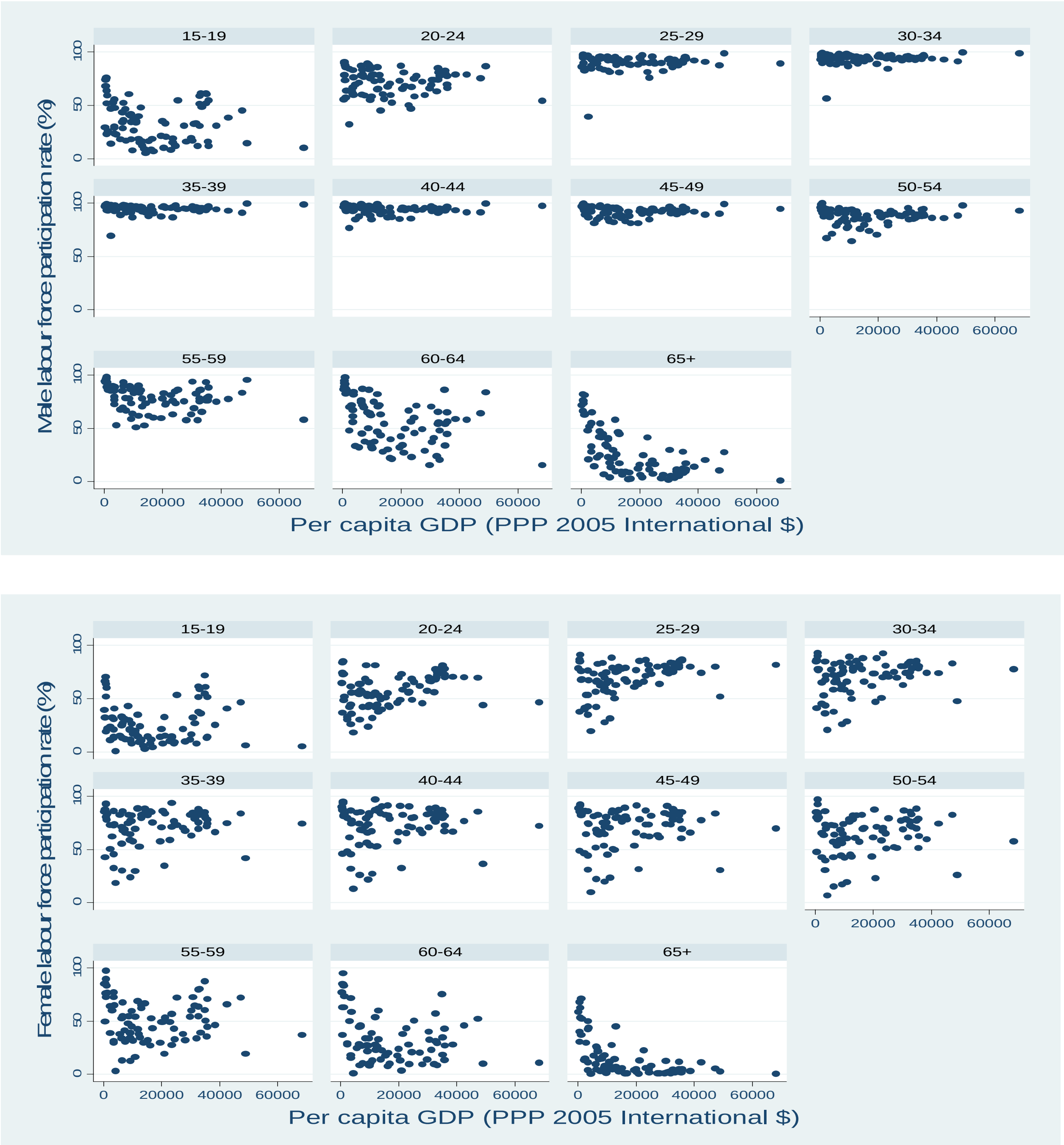
[19] Covariate selection was done separately for each of the estimation groups. Full regression results corresponding to the EAPEP Version 5 database are published in Kapsos (2007).

[20] See also Nagai and Pissarides (2005), Mammen and Paxon (2000) and Clark et al. (1999).

[21] Whereas economic development in the poorest countries is associated with declining labour force participation (particularly among women and youth), in the middle- and upper- income economies, growth in GDP per capita can be associated with rising overall participation rates – often driven by rising participation among newly empowered women. This phenomenon is the so-called "U-shaped" relationship between economic development and participation. See ILO, KILM 4th Edition and Mammen and Paxon (2000).

[22] See Nagai, L. and Pissarides (2005), Fortin and Fortin (1998) and McMahon (1986).

Figure 2. Labour force participation rates by sex and age-group, and per capita GDP, 2005 (83 countries with reported data)



Note: 2005 is selected because it represents a pre-crisis year for which the response rate is the highest.
Source: KILM 1b, 7th Edition

Changes in the age-structure of populations can also affect labour force participation rates over time. This happens at the country-wide level, since different age cohorts tend to have different labour force participation rates, and thus changes in the aggregate age structure of a population can affect the overall participation rate. More importantly for the present analysis, however, is the potential impact that demographic changes can have on intra age-group participation rates within countries. Changes in population age structure can affect the overall burden for caring for dependents at home, thus affecting individuals' decisions to participate in labour markets. This can have a particularly important effect on women's decisions to enter into work.[23] In order to incorporate these types of demographic effects, the share of population aged 0-14 (young age-dependent), 15-24 (working-age youth) and 25-64 (prime working age) were incorporated to varying degrees in regions in which an important relationship between participation and demographics was found. These variables are by definition correlated and thus increase the presence of multicolinearity in the regressions. However it was determined that this did not present a prohibitively significant problem in the context of the present estimation procedure.

In all estimation groups, a set of country dummy variables was used in each regression in order to capture country fixed effects. A preliminary examination of the input data revealed that countries in the South Asia estimation group exhibit a particularly large degree of heterogeneity in labour force participation rates, especially with regard to female participation. In order to estimate robust labour force participation rates in non-reporting countries in this estimation group, it was necessary to introduce a dummy variable to further subdivide economies in the region based on observed national labour market characteristics and prevailing cultural norms with regard to male and female labour market participation. This variable was significant in more than 70 per cent of the regressions carried out for the estimation group. Finally, the constant $\alpha_{i,}$ given in equation 8 is country-specific and captures all the persistent idiosyncratic factors determining the labour force participation rate in each country. For 11 out of the 17 countries which do not have any reported comparable labour force participation rates over the 1980-2010 period the fixed effect of a counterpart economy has been chosen instead of the regional average. The end result of this process is a balanced panel containing real and imputed cross-country comparable labour force participation rates for 191 countries over the period 1980-2010. Furthermore, for the above mentioned 17 countries a smoothing procedure similar to the one described in Annex 3 has been applied in order to achieve consistency across age groups.[24] In the final step, these labour force participation rates are multiplied by the total population figures given in the United Nations World Population Prospects 2010 Revision database, which gives the total labour force in each of the 191 countries, broken down by age-group and sex.

Step 5: Judgmental adjustments

For a few countries, the estimates derived from the weighted panel model (see previous section) have been adjusted when the estimates were not judged to be realistic by analogy to real data observed in similar countries.

This happens notably for some countries for which the proxy variables used in the panel model are poor proxies of the determinants of changes in LFPR. Cases in point include countries with a very volatile GDP over time, due to a strong dependence on oil or other mineral commodities (copper, gold). In this context, the trends derived from the panel model are often too volatile.

[23] Bloom and Canning (2005), Falcão and Soares (2005), O'Higgins (2003), Clark et al. (1999), Fullerton (1999) and McMahon (1986) provide some examples of the relationships between population structure (and demographic change) and labour force participation rates for different groups of the population.

[24] This is necessary because equation 8 runs separately for males and females and for the several age groups. Hence, the current model cannot assure consistency across the life span.

4. Projection: 2011-2020

4.a. Methodologies used worldwide

The ILO Department of Statistics recently undertook a literature review of all the EAP projection models used and developed by national statistical offices and international organizations[25]. Notably, this document contains a description of the approach adopted by each national or international institution. A two page template has been used to describe the following aspects: the name of the institution, the frequency of updates and projection horizon, a brief description of the current methodology, the determinants that are captured explicitly, the use (or not) of scenarios, the assessment (or not) of the current methodology, the existence of any previous methodology, reference papers and additional comments. Some major findings of this literature review are presented in this section.

To project LFPRs, four types of approaches have been identified in this document:

(A) Judgmental (or qualitative) methods based on scenarios or on the targets to be reached.

(B) Time extrapolation models or growth curves. Values for the measured variable can be expressed as a function of time and extrapolated over the projection period. There are many growth curves routinely used in the analysis of growth processes that ultimately reach a steady state. These generally form a class of s-shaped or sigmoid curves, of which the most commonly used is the logistic curve. These sigmoid curves are very useful for modelling populations, labour force participation rates, inflation, productivity growth (not levels) or other processes where, in the long run, it is expected that the variable will not grow any further.

(C) Regression models based on correlations between participation rates and economic, demographic or cultural factors. A regression model with a set of explanatory variables is fitted on observed LFPRs. Future scenarios for the explanatory variables are determined and used in the regression model to project LFPRs.

(D) Models based on a cohort approach. In this case, LFPRs are not projected by age and sex year after year, but they are projected from the estimated probability of entry or exit of the labour force for each age, sex and cohort (people born in a specific year). More specifically, the probability of entry and exit of the labour force are kept stable at the last observed value or are extrapolated over the projection period for each population cohort.

Table 5 lists the type(s) of methodology used by each national or international institution. It can be seen that judgmental and time extrapolation methods are the most frequently used. The main reason is of practical nature: these methods can be implemented more easily. The other approaches are more time-consuming.

Regression models are often statistically complex; they can be "heavy users" of historical and projected data. They rely on the accuracy of projected explanatory variables and the choice of the later can be a difficult and strategic process, for example when they change over time.

Cohort based-models need historical data over a long period to be implemented. Ideally, it should be pure longitudinal data (the same people surveyed year after year) but in fact, most of the projections are based on annual surveys based on different surveyed households. In addition, statistical procedures for projecting the cohorts' rates of entry or exit of the workforce quickly become complicated.

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[25] For more details see Houriet-Segard and Pasteels (2011).

Table 5. Summary of projection methods used worldwide

Type of projections /Projection models	Judgmental approach (target or scenarios)	Time extrapolation approach	Regression approach	Cohort based approach	Additional modules
Algeria	X				
Asian Development Bank			X		
Australia Bureau of Statistics		X			
Australia GPG				X	
Bolivia	X				
Canada		X			
CELADE	X				
European Central Bank			X	X	
European Commission				X	X
EUROSTAT	X				
France		X	X		X
Haiti	X				
Hong Kong		X			
ILO (edition 5)	X	X			
Ireland	X				
Mexico				X	
New Zealand	X				
OECD				X	X
Singapore		X			
Spain			X	X	
Sri Lanka	X				
Switzerland			X		
Tunisia	X				
United Kingdom		X	X		
USA		X			

Judgmental determination of projected participation is actually the only option for countries where there are not enough or no comparable historical data to model LFPR, as well as for countries with complex patterns of LFPR that cannot be easily modelled.

Time extrapolation methods are statistically easy to develop and only need a consistent time series. However they suffer from several drawbacks. Firstly, they only extrapolate past patterns without being able to project changing trends in the future. Fundamentally, the model is meant to implicitly capture as whole all demographic, economic and cultural effects affecting LFPR. In other words, it consists of using a reduced form of an ideal model that would capture all the determinants separately. Finally, possible inconsistencies between projections of different subgroups of the population can occur.

4.b. Methodology used in this edition

In this edition the ten years-ahead projections are derived from a **three steps** procedure that uses both mechanic and judgmental approaches. The choice of a combination of mechanic and judgmental approach is justified by the review of the literature and the context: a large number of time series have to be modelled (more than 4'000) and the dataset contains many missing values (only 28 per cent of available records).

The first step consists of applying six mechanic models for each time series of LFPR for a given country, a give age group and gender. The reasons why these six mechanic models have been chosen are explained in the first section.

In the next step, the projections obtained from the six mechanic model are combined using a weighted average. The principle, with its pros and cons, of combining forecasts is presented in section 2 as well as the set of weights used for each subgroup of the population.

During the third phase, the combined projections are adjusted judgmentally in order to obtain consistent LFPR across gender and age groups for each. This aspect is critical as each time series is modelled independently. By construction there is no guarantee of consistency across gender and age groups. The third section explains the different criteria and rules of thumb that are applied.

The different steps of this methodology have been tested and implemented on the basis of *ex-ante* and *ex-post* experiments. *Ex-ante* tests (before the action) consist of comparing the results obtained by this methodology with the projections published recently by NSOs. *Ex-post* (after the action) experiments consist of dropping the last observations of a time series, then deriving projections on the basis of the shortened time series and calculating and analysing the ex-post (also called "post-sample") error projections. The results of these simulations are presented respectively in Annexes 5 and 6.

Step 1 – Mechanic projections

For each time series, several projections are derived from different model specifications (extrapolative and panel regressions), including a model specification that allows the capture of the impact of the latest economic crisis (still on-going in some countries) on the labour force participation rate for concerned countries.

The different models that have been used are the following:

(1) Panel model used for deriving the estimates (weighted multivariate estimation)

(2) Pre-crisis participation rate (average of 2006 and 2007)

(3) Transformed trend with a narrow range of asymptotes

(4) Transformed trend with a wide range of asymptotes

(5) Transformed trend with a wide range of asymptotes, estimated at the level of large age-groups

(6) Cyclical changes around a transformed trend (wider range of asymptotes)

Model 1 is the weighted multivariate estimation presented in section 2. Projections based on this model will notably be applied for countries for which it is already used to fill the missing historical data.

Models 2 to 5 are purely extrapolation methods (that use only historical data). Model 2 consists of the pre-crisis LFPR (average of 2006 and 2007). It is a variant of a naive forecast (that the value for next year is expected to be the same as the previous year). It allows the capture of a scenario of return of LFPR to its pre-crisis level on the forecasting horizon (2020 and before).

Models 3 to 5 are variant forms of the same basic model. The parametric form for the basic model is linear but fitted to the logit (logistic transformation) of the proportion participating, scaled to fit between the values y_{min} and y_{max} (the asymptotes) determined for each age-sex group in a separate step. In this model, the participation rate y_t at time t is then given by

$$y_t = y_{min} + \frac{y_{max} - y_{min}}{1 + e^{a+bt}} \quad \text{[p.1]}$$

It can easily be demonstrated that the transformed variable y'_t , defined as $y'_t = \frac{y_t - y_{min}}{y_{max} - y_{min}}$ [p.2], is equal to the following expression: $y'_t = \frac{1}{1 + e^{a+bt}}$ [p.3]

Then, the transformed variable Y'_t, is defined as the logistic transformation of y'_t:

$$Y'_t = \ln(y'_t/(1-y'_t)) \quad \text{[p.4]}$$

It can also easily be shown that $Y'_t = -(a + bt)$. Consequently, the parameters *a* and *b* can be estimated by running a linear regression on Y'_t.

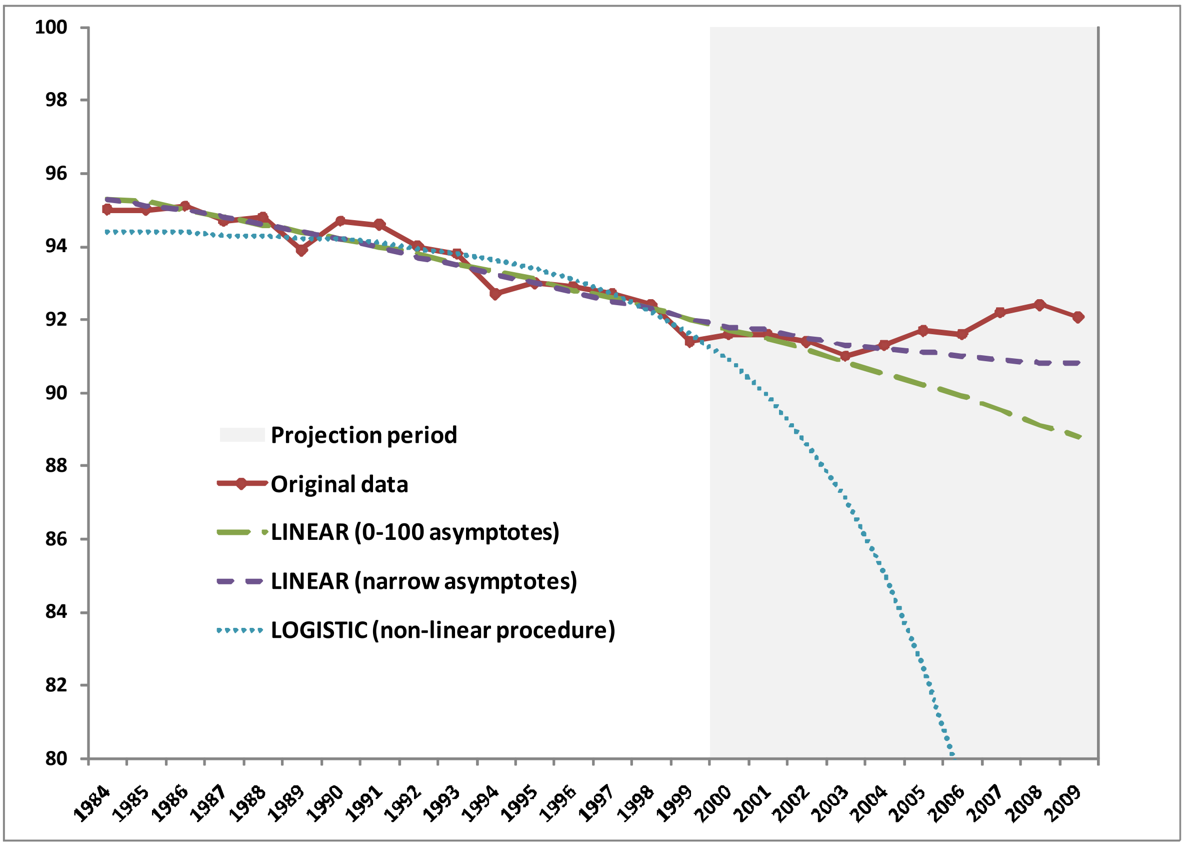
A special case is when $y_{min} = 0$ and $y_{max} = 1$ (the participation rates can vary between 0% and 100%). In this case, $y_t = y'_t$ and Y'_t corresponds to the same logistic transformation used in the estimation phase (see section 2).

This basic model was used in the previous edition of the projections (see ILO 2009). The way to define the asymptotes simply differs in this edition. It is a very convenient model, which combines the advantages of a logistic curve without suffering from its drawbacks.

The main advantage of the logistic curve and other sigmoid or S-shaped curves is that they can capture growth processes that ultimately reach a steady state. These curves are frequently used for modelling populations and labour participation rates.

The S-shaped curves, however, are not very easy to estimate. The logistic curve can be estimated using non-linear least squares and maximum likelihood techniques. However, there are often problems in convergence and sometimes convergence cannot be achieved. In addition, imprecise estimates are obtained if the data does not clearly include an inflection point, i.e., the time at which the absolute value of the growth rate is maximised (for more details see Kshirsagar & Smith 1995). Estimating a logistic function on such data without imposing an assumption about when the inflection will occur will sometimes give nonsensical results. Figure 3 shows an example of unexpected projections of male LFPR obtained from a logistic curve.

Figure 3: Australia: Male LFPR (Age group: 35-39). Projections based on growth curves vs real data



With this basic model, the method for defining the asymptotes is crucial. In the previous edition (see ILO 2009) the asymptotes were determined by looking jointly at the patterns of male and female participation rates for the same age group. The main assumption being that the past convergence or divergence between male and female LFPRs would continue in the future at the same pace as over the last ten years. This approach has been abandoned as it resulted in too many unexpected results (e.g., strong decreases in male LFPRs in the prime age, increased divergence between female and male LFPRs). More fundamentally, the assumption of continued joint divergence or convergence of male and female LFPRs is not fully justified theoretically, as many of the determinants of male and female LFPRs differ and the two rates may often move independently.

In this edition, it was decided to empirically test different alternative ways to set the asymptotes and to use the most appropriate set of asymptotes for each of the 22 subgroups of the population.

The simulation showed that working with two sets of asymptotes is enough: a narrow range of asymptotes where not much change is expected in the future and a wider one that allows larger changes in LFPR in the projection horizon. Figure 3 shows that the narrow range is well suited to male LFPR in the prime age. This is also confirmed by ex-post simulations (see Annex 6). It is also worth mentioning that the two variants will give very close results when there is a flat trend.

For each time series, the set of asymptotes are defined as:

$$y_{min} = \min(y_t) - \lambda \cdot \varepsilon \quad \text{and} \quad y_{max} = \max(y_t) + \lambda \cdot \varepsilon \qquad [p.5]$$

Where λ is set to 1 if for the narrow range of asymptotes and set to 1.5 for the wider range of asymptotes. The value of ε represents the average absolute error of the naive method at the horizon of 10 years. It is calculated for each time series as follows:

$$\varepsilon = \frac{\sum_{t=t_0+10}^{t_1} |y_t - y_{t-10}|}{n} \qquad [p.6]$$

Where t_0 is the first year and t_1 the last year ($n=t_1-t_0$). In other words, ε is a measure of volatility of the time series over ten year time intervals.

For countries with many data gaps, the value of ε is based on the sample of countries used to undertake the ex-post simulations (Annex 6). For example, for a sample of 22 countries, the value of ε is estimated at around 1 percentage point for male LFPR aged 30 and 49. This means that the LFPR is extremely stable over time and should not deviate more than 1 percentage point above its maximum past value and below its minimum past value in the next 10 years.

For female LFPR, values of $y_{min,f}$ and $y_{max,f}$ are also further adjusted (when necessary) in order to guarantee some consistency with the asymptotes estimated for male LFPR: $y_{min,m}$ and $y_{max,m}$. More specifically, it consists of the following rules:

(i) impose $y_{min,f} = y_{min,m}$, if $y_{min,m} <= y_{min,f}$

(ii) impose $y_{max,f} = y_{max,m}$, if $y_{max,m} <= y_{max,f}$ and if $y_{t,m} > y_{t,f}\ \forall\ t$

(iii) impose $y_{max,f} = y_{max,m}$, if $y_{max,m} <= y_{max,f}$ and if $y_{max,m} > y_{t,m}\ \forall\ t$

Model 5 is similar to model 4 but what changes is simply the time series that is modelled. The principle is to undertake modelling for a larger subgroup of the population (eg. 25-54), to derive projections at that level and to apply the growth rates of the projected aggregate for each 5-year age band subgroup. By construction, the projections for each 5-year age band will grow at the same pace. For male LFPR, the larger age bands are defined as [15-24], [25-54] and [55+]. For female LFPR, there are four larger age bands ([15-24], [25-39], [40-54] and [55+]). The prime age group [25-54] has been subdivided into two groups in order to take into account of the impact of maternity on LFPR.

Model 6 is a model that attempts to distinguish long-term trends from short-term changes due to changes in the business cycle. This approach has been adopted in a few countries. Notably, the NSO in the UK (see Madouros 2006 for more details), uses the following basic model:

$$y_t = f\left(GAP_t, T, DUMMY_t, \sum_{k=1}^{n} y_{(t-n)}, \right) \quad [p.7]$$

where GAP_t is the output gap at time t and T is the time trend. The observed LFPR is described as a function of a trend term (which is clearly driven by many diverse influences at the micro-level) and some measures of the economic cycle. For some specific sub-groups, some additional dummy variables ($DUMMY_t$) are added to the basic model to account for special government policies that had an impact on activity rate series.

Formally, model 6 is defined as:

$$y_t = y_{min} + \frac{y_{max} - y_{min}}{1 + e^{\alpha + \beta t + \gamma C_t^+ + \delta C_t^- + \kappa D_t C_t^-}} \qquad [p.8]$$

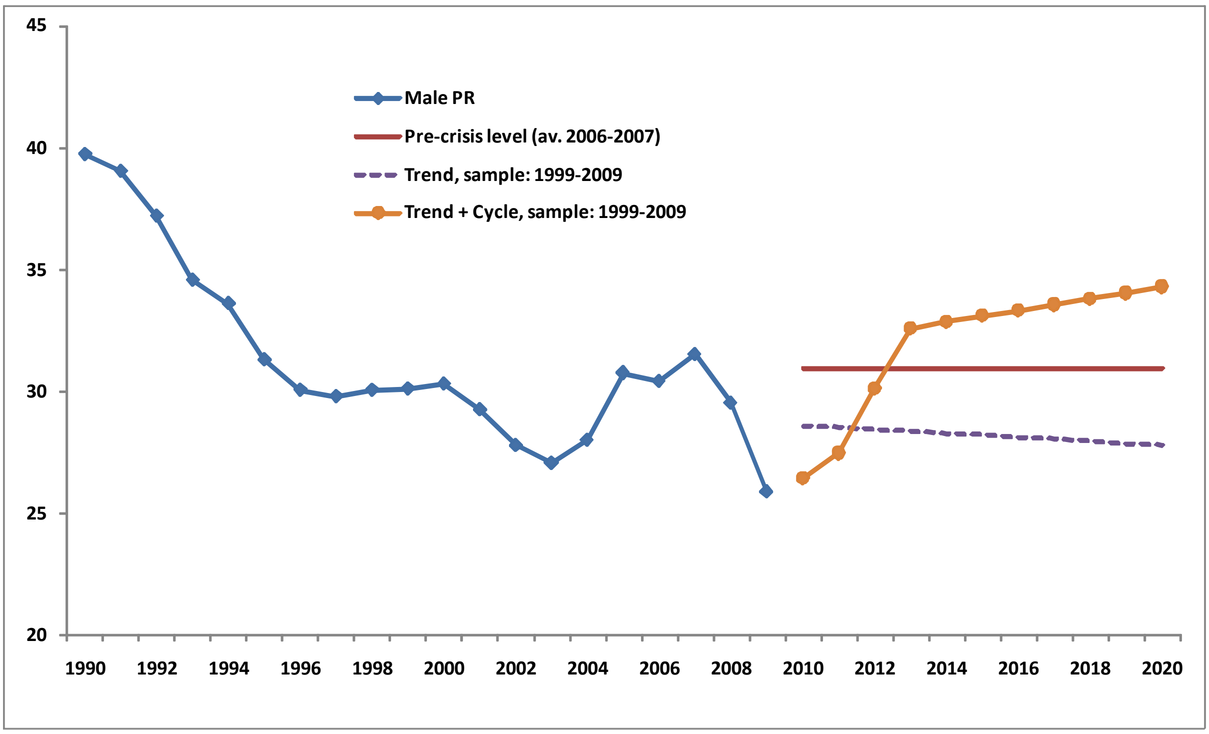
where C_t^+ and C_t^- are two measures of the output gap, respectively, positive and negative values of the output gap (C_t^+ is set to 0 when the output gap is negative). The use of two variables for measuring the cycle allows asymmetric responses to cyclical changes, as presented by Bell and Smith (2002).

The dummy variable D_t equal 0 before 2008 and 1 after. Since it is used in combination with C_t^-, it captures changes in LFPR specific to the latest crisis, which might be different from previous crises. As highlighted by OECD (2010), it notably concerns the population in pre-retirement age, which was pushed out of the labour force in many countries during previous crises through pre-retirement measures, but not during the 2008 crisis (which is still ongoing in some countries).

The output gap is estimated using the Hodrick Prescot filter, applied to real GDP figures published by the IMF. Since IMF forecasts are only available until 2015, the output gap is set to 0 for the period ranging from 2016 to 2020.

Figure 4 illustrates the difference in projections that can be obtained in some cases between a pure trend and a trend+cycle model. As highlighted in section 1, cyclical effects are expected be more important among younger groups of the population.

Figure 4: SPAIN: projection of Male participation rates, age group 15-19



Step 2 – Combination of mechanic projections

The different projections are combined according to specific weights that have been calibrated on the basis of ex-ante and ex-post simulations.

Combining forecasts is an approach frequently used by forecast practitioners. Many empirical studies have been undertaken on the subject. Notably, see the reviews undertaken by Clemen (1989) and Armstrong (2001). As stated by Armstrong (2001), "*Combining forecasts is especially useful when you are uncertain about the situation, uncertain about which method is most accurate, and when you want to avoid large errors. Compared with errors of the typical individual forecast, combining reduces errors".*

It is also worth mentioning that there is a debate between practitioners and researchers. As summarised by Armstrong (2001), "*Some researchers object to the use of combining. Statisticians object because combining plays havoc with traditional statistical procedures, such as calculations of statistical significance. Others object because they believe there is one right way to forecast. Another argument against combining is that developing a comprehensive model that incorporates all of the relevant information might be more effective.... Despite these objections, combining forecasts is an appealing approach. Instead of trying to choose the single best method, one frames the problem by asking which methods would help to improve accuracy, assuming that each has something to contribute. Many things affect the forecasts and these might be captured by using alternative approaches. Combining can reduce errors arising from faulty assumptions, bias, or mistakes in data.*"

The different empirical experiments also reveal that combining forecasts improves accuracy to the extent that the individual forecasts contain useful and independent information. Ideally, projection errors would be negatively related so that they might cancel each other out. In practice however, projections or forecasts are almost always positively correlated.

As illustrated in detail in Annex 6, the results from ex-post simulations indicate non-negligible gains in projection accuracy when combining projections. The gains are obvious for projections of male LFPR. However, for female LFPR, the tested combinations did not perform as well.

The weights used in this edition are based on the results from the ex-ante and ex-post experiments as well as two additional factors; the availability of historical data (at least 50% of historical records available for each time series) and the extent to which the country faced a recession or not since 2008.

The weights are displayed in Table 6. In general, the highest weight is attributed to the constrained trend computed at the large age band level (model 5), which performed well during the simulations. When there are not enough observations, the "Trend+Cycle" model is not used, since there are not enough observations to perform a correct decomposition. For the sake of consistency, the panel model is used when there are not enough data, as this model is also used to fill the missing data.

The pre-crisis level (a form of a naive method) is used in context of a recent recession in conjunction with a lack of a complete time series. Finally, for the 55-64 and the 65+ age bands, the weights allocated to cyclical fluctuations are very low, since the determinants of a structural nature are more important in explaining changes in participation rates for this group of the population.

Table 6. Weights used for the combined projections

				Weights					
Set	**Age group**	**Enough available data**	**Recession since 2008**	**1. Panel model**	**2. Pre-crisis level**	**3. Constrained trend (narrow range)**	**4. Constrained trend (wide range)**	**5. Constrained trend, large age-band**	**6. Trend+Cycle**
1	15-54	yes	no			20%	20%	40%	20%
2	15-54	yes	yes			20%	20%	20%	40%
3	15-54	no	yes	25%	25%	25%		25%	
4	15-54	no	no	30%		30%		40%	
5	55-64	no	yes/no	50%			30%	20%	
6	55-64	yes	yes/no			20%	20%	40%	20%
7	65+	yes	yes/no				10%	90%	
8	65+	no	yes/no	50%				50%	

Note: an empty cell means a weight equal to zero for the corresponding model.

Step 3 – Judgmental adjustment

In a third phase the projections are adjusted judgmentally according to several criteria. The projections should be consistent across gender and age groups. This aspect is critical as each time series is modelled independently. By construction there is no guarantee of consistency across gender and age groups. The difficulty lies in defining a consistent set of projections for a country since many structural changes can occur over the projection horizon. The following rules of thumb have been applied:

(i) In terms of gender consistency, we assume that there should be **no change of sign** in gender difference (male – female LFPR of the same age) over the projection horizon for the prime age (25-54) if the gender difference was always of the same sign in the past.

(ii) For males, LFPRs for all 5-year age bands in the prime age (25-54) are expected to move in the same direction (same trend sign).

(iii) For females, LFPRs for all 5-year age bands included in the interval (35-54) are expected to move in the same direction (same trend sign).

(iv) In an ageing population, the LFPRs of 55-64 are expected not to decrease more or grow slower than that of the prime age (25-54).

(v) It is not expected to observe a decrease in LFPRs across all sub-groups of the population. Empirically, a decrease in LFPR in a subgroup of the population is usually compensated by an increase in at least one other subgroup.

Those rules are based on empirical findings. For example, in the whole dataset (excluding any imputed data), there are around 0.9% of observations with female LFPRs superior to male LFPRs at the level of 5 year- age bands. Outlying countries are Liberia, Sierra Leone, Barbados, Belarus, Bulgaria, Estonia, Latvia, Lithuania, Republic of Moldova and Slovenia.

The adjustments are also done on the basis of exogenous information such as:

a) Projected share of population aged 0-14 and 55+ in total population and the projected share of female population in total population (Source: UN).

b) Proportion of immigrant workers in the country (National sources).

c) Forthcoming changes in retirement and pre-retirement schemes and any other policy or legal determinants (National sources).

d) HIV prevalence (international estimates).

For a dozen countries, the ILO uses projections made by National Statistical Offices, provided that these have been published recently. This concerns around twelve countries.

Linearization of projections between the projection origin and target

Once the final projections at the horizon 2020 are computed, the intermediate values from the projection origin (2010) and the target (2020) are filled assuming a linear pattern. This assumption may not be the most appropriate for all countries and groups of the population, but it has been decided to apply this simple rule for the sake of consistency across all countries, in the absence of alternative solutions applicable to all time series.

This linear interpolation implies that users of the projections should have higher confidence in the participation rate projected at the horizon 2020 than in intermediate values.

5. Strengths, limitations and future work

In this edition, the priority is to fully exploit information reported by NSOs, even if some adjustments need to be made.

For the sake of continuous improvement, the strengths and weaknesses of this edition are described hereafter.

5.a. Strengths

(i) The data have been harmonised and are comparable across countries.

(ii) Detailed metadata for the estimates are provided for each data point.

(iii) Projections made by NSOs are used when available and published recently. These projections are expected to integrate more country-specific expertise.

(iv) Consistency by gender and age group has been checked systematically.

(v) For the sake of transparency, the different mechanical projections (based on different assumptions) are provided in electronic format for users who would like to compare them and possibly select alternative assumptions.

5.b. Limitations

A limitation that concerns both estimates and projections is that the **degree of confidence** regarding each published data point varies significantly across country. The confidence in each data point depends on the availability and consistency of historical data. However, in this edition, no confidence intervals are published since the final estimates and projections are derived from various steps.

There are two extreme sets of countries: the ones for which historical data are available in a consistent manner over time (e.g., OECD countries) and those for which there is no consistent historical data at all (the list of 17 countries mentioned in section 2). It is advised to consider the estimates and projections derived for the later group as purely indicative.

The other limitation is that both panel regressions and projection methods are modelling each time series (LFPR by age group and by sex) **independently** and the consistency is checked afterwards, making the exercise extremely time consuming.

<u>The limitations specific to the estimates are the following:</u>

(a) The proportional adjustments made in order to harmonise the data have some limitations, since in the absence of complete information over time, some simplifying assumptions of constant patterns over time have to be made. An example of this limitation is the following. In the case of harmonisation adjustments of age band 16-19, applying the proportional adjustment based on US data for other countries supposes a priori similar patterns between the US and those countries, and similar changes over time. However, the proportion of 15 year olds that work compared to the 16-19 age group, may differ from the US proportion, simply due to different policies regarding apprenticeships and other work-study programmes.

(b) Some adjustments have not been made in this edition. Cases in point are the exclusion of military forces and prisoners from the surveys and the use of different reference periods (whole year, month).

(c) The linear interpolation and the weighted panel regressions are not based on the same assumptions. The linear interpolation assumes that the changes in LFPR due to cyclical and accidental factors are negligible compared to structural ones.

(d) Concerning the panel regressions, there are many regression models (176, 11 age groups x 2 sexes x 8 regions). It is time-consuming to modify the models and there are not enough data for some regions (eg. Sub-Saharan Africa), making the estimates not enough robust. In addition, the GDP per capita is too volatile for a few economies that rely strongly on oil and/or other mineral commodities. In this context, it becomes a poor proxy for what it is meant to capture (wealth per inhabitant, existence of social security schemes, access to education, etc.).

(e) The parameters of the panel models are run on the sample of historical data plus the interpolated data.

<u>The limitations specific to the projections are the following:</u>

(a) The main limitation is that the tests and simulations (ex-ante and ex-post) are based on a limited sample of countries that may not be representative of all countries under analysis. This is a problem common to all calibration techniques (parameters are calibrated on a sub-sample of countries). Unfortunately, forecasting simulations cannot be performed on countries lacking data or with time series with significant data gaps.

(b) By conception, any mechanic model has its shortcomings. Extrapolative models have well-known shortcomings as described in the previous section.

(c) The "Trend + cycle" model sometimes resulted in strange results. This might be due to the use of annual data. The decomposition of a time series in trend and cycle components is usually suited to lower-frequency data (quarterly or monthly data).

(d) The judgmental adjustment described in the previous section may be too conservative in a few cases. In other words, they may under-estimate changes in LFPR.

5.c. Direction for future work

Future work should address each of the above mentioned limitations, bearing in mind the costs and benefits of each improvement.

As mentioned above, more adjustments could be done in the future (exclusion of military forces and prisoners from the surveys and the use of different reference periods).

Also, for some countries for which there is no data at all, micro-datasets of third countries could be used as an alternative to econometric models (e.g., using micro-data from some regions in Pakistan for estimating LFPR in Afghanistan).

Regarding the estimating phases, the number of estimation models could be reduced and dummy variables for sub-regions and for countries with similar labour markets (e.g., in terms of share of immigrant workers, proportion of female population in the prime age, oil-based economies) could be added. Ideally, the regressions would be estimated only on the basis of historical data and linear interpolation should no longer be used as such. Also, some other structural variables can be considered (literacy rates, life expectancy, educational variables), provided that complete time series are available. Another track to explore is to impose some consistency between estimates of different subgroups of the population. For example, it would be worth trying to model the LFPR at a more aggregate level (e.g., at the prime age model 25-54) rather than at the 5-year interval level.

Finally, in an ideal world, the processes for estimating and projecting the LFPRs would be derived from a common model. Different model specifications could be imagined for different country groupings which would be defined on the basis of available data.

6. Presentation of the estimates and projections

Different documents in different formats are available from the website: http://laborsta.ilo.org

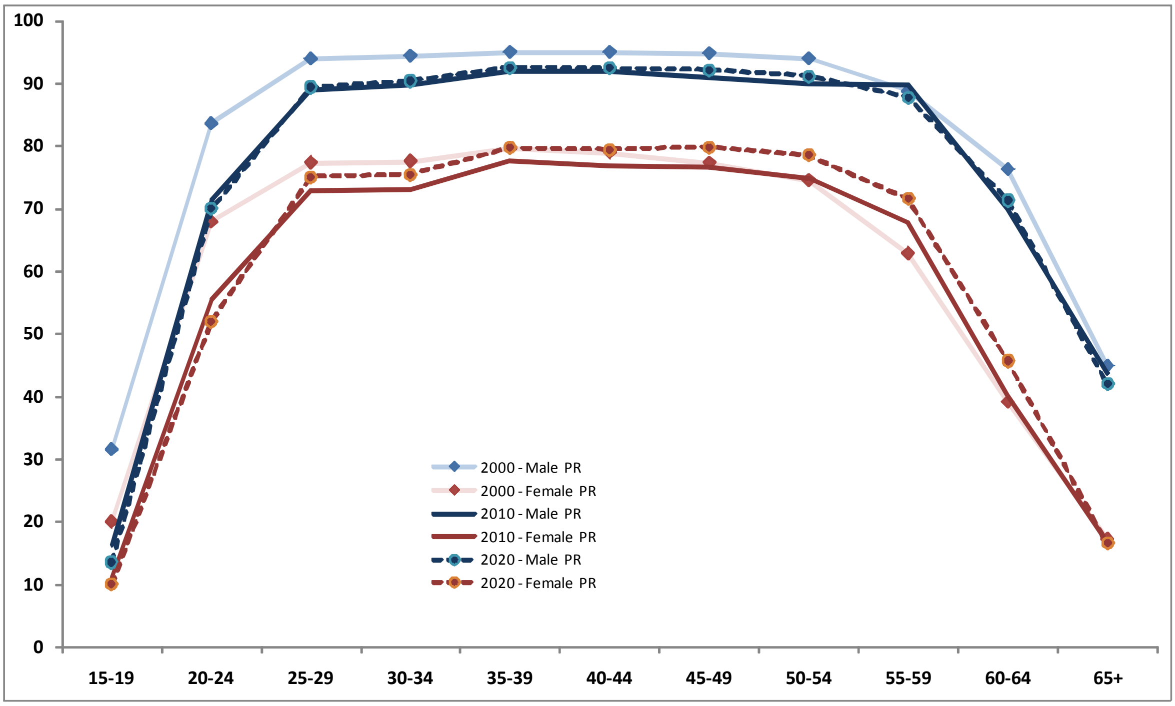
The user will find:

- Harmonised datasets (1990-2020) with selected metadata
- Pivot charts for all countries
- More complete datasets (1980-2020) with detailed metadata and projections from various models
- Background documents (including this paper)

The section presents a few examples of analytical charts that are available for all countries when clicking on the "Pivot charts" link.

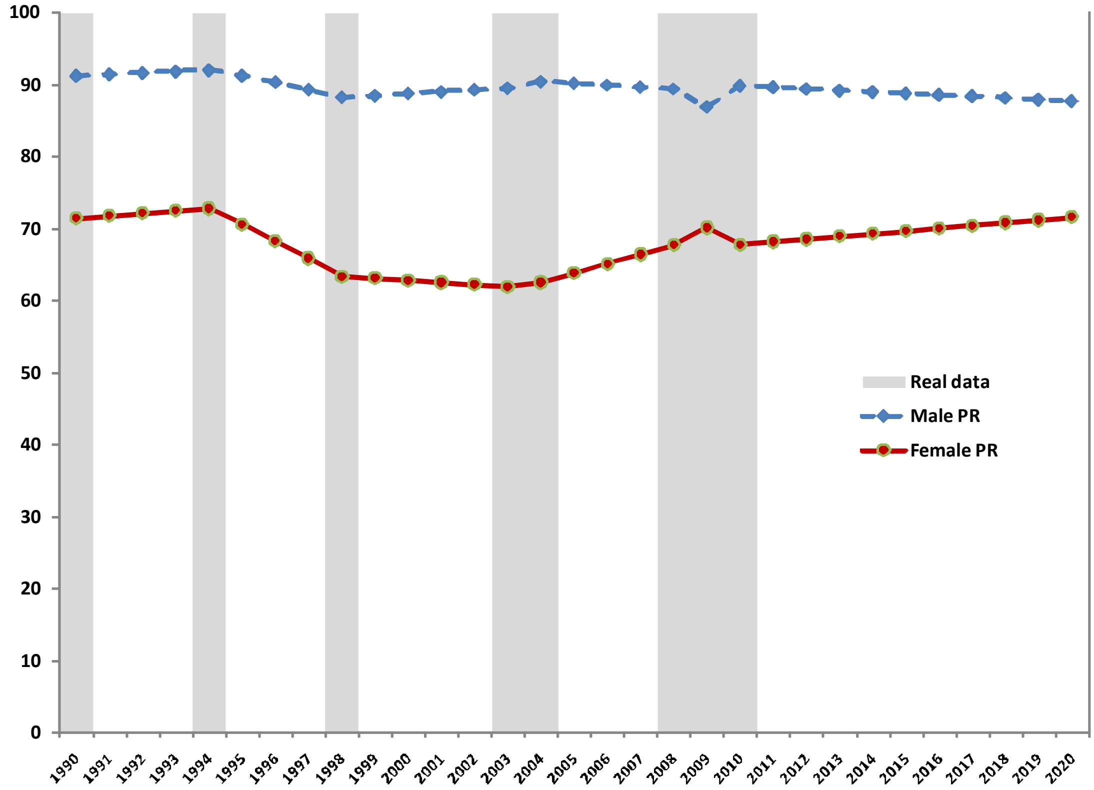
The different pivot charts are available using the format of excel 2007 and above. The first sheet displays a distribution of LFPRs by age band for a selected country for different years (see Figure 5).

Figure 5: Example of distribution chart. Distribution of LFPR by age band for Jamaica for selected years



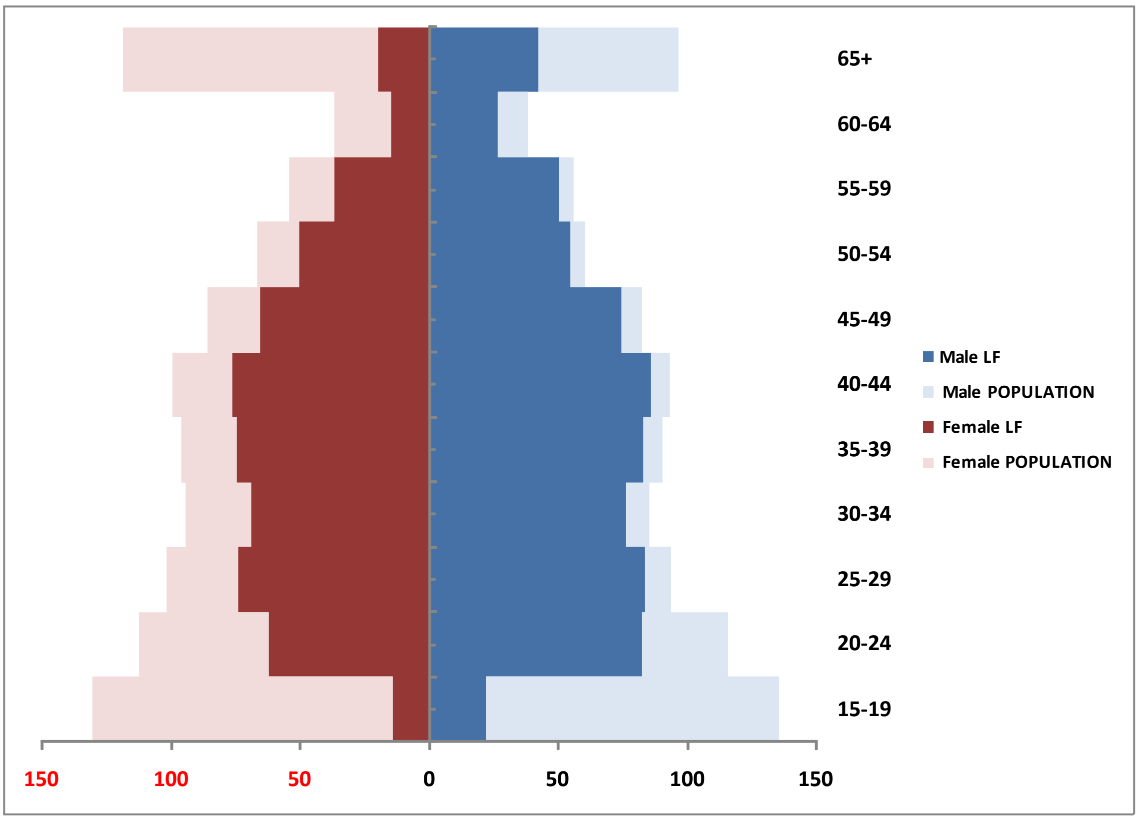
The second sheet allows the display of male versus female LFPR over time for a given country and a selected age band. Shaded areas indicate that original data are available for the corresponding year(s).

Figure 6: Example of time series plot. Male and female LFPR for the 55-59 age band in Jamaica



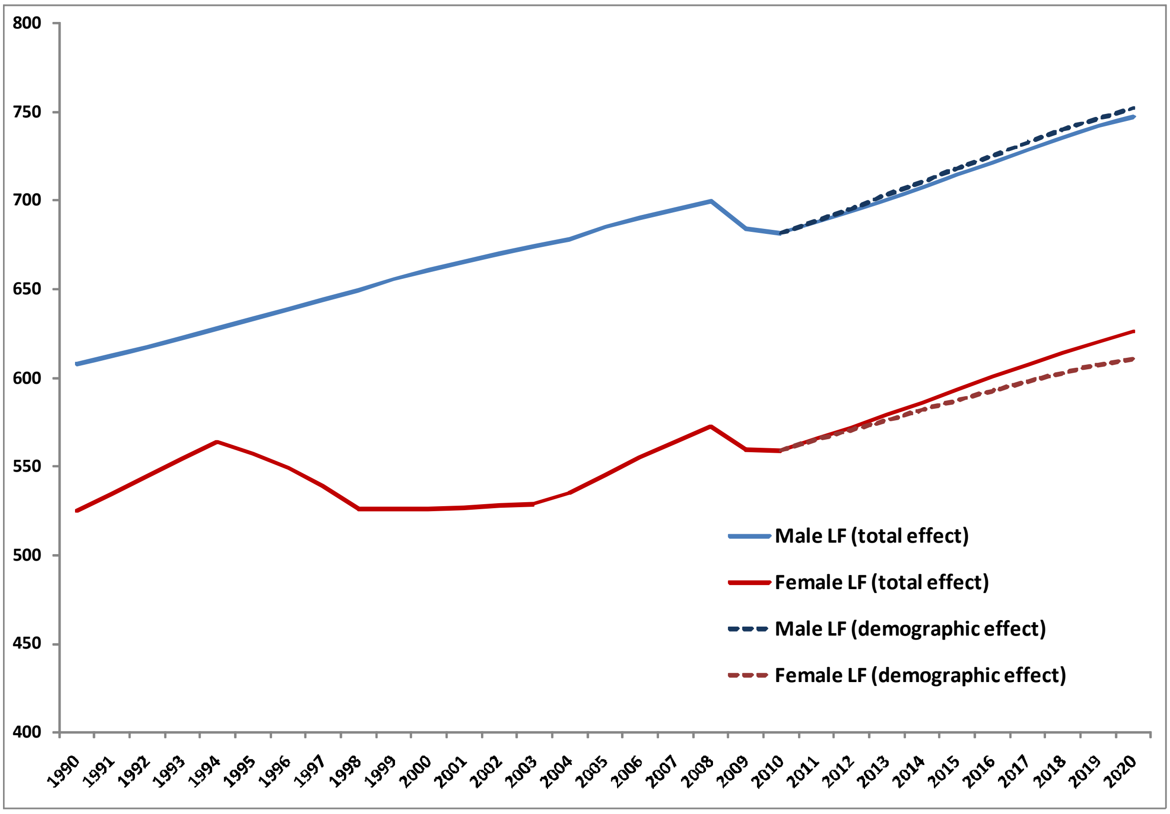
The third sheet allows the display of a population pyramid, comparing the population and the economically active population for a given country and year. It is worth mentioning that it is not a true population pyramid since the age band "65+" is larger than a five-year age band.

Figure 7: Example of pyramid chart for Jamaica in 2010



Finally, the last sheet presents at the aggregated level (for 15 years and above), the decomposition of the projected changes in labour force due to a pure demographic effect (assuming that the LFPR for each subgroup would be constant and equal to those observed in 2010) and an activity effect. In other words, the curves shown in dotted lines indicate the projected LF when naive forecasting (recommended for a random walk process) is used as a projection method. The difference between the two curves (total versus demographic) represents the changes in LF since 2010 solely due to changes in participation rates.

Figure 8: Example of time series plot for the total working age population for Jamaica



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ANNEX 1: Country composition of each sub-regional grouping

AFRICA

Eastern Africa	Burundi ; Comoros ; Djibouti ; Eritrea ; Ethiopia ; Kenya ; Madagascar ; Malawi ; Mauritius ; Mozambique ; Rwanda ; Réunion ; Somalia ; Tanzania, United Republic of ; Uganda ; Zambia ; Zimbabwe
Middle Africa	Angola ; Cameroon ; Central African Republic ; Chad ; Congo ; Congo, Democratic Republic of ; Equatorial Guinea ; Gabon ; Sao Tome and Principe
Northern Africa	Algeria ; Egypt ; Libyan Arab Jamahiriya ; Morocco ; Sudan ; Tunisia ; Western Sahara
Southern Africa	Botswana ; Lesotho ; Namibia ; South Africa ; Swaziland
Western Africa	Benin ; Burkina Faso ; Cape Verde ; Côte d'Ivoire ; Gambia ; Ghana ; Guinea ; Guinea-Bissau ; Liberia ; Mali ; Mauritania ; Niger ; Nigeria ; Senegal ; Sierra Leone ; Togo

NORTHERN AMERICA Canada ; United States

LATIN AMERICA AND THE CARIBBEAN

Caribbean	Aruba ; Bahamas ; Barbados ; Cuba ; Dominican Republic ; Grenada ; Guadeloupe ; Haiti ; Jamaica ; Martinique ; Netherlands Antilles ; Puerto Rico ; Saint Lucia ; Saint Vincent and the Grenadines ; Trinidad and Tobago ; Virgin Islands (US)
Central America	Belize ; Costa Rica ; El Salvador ; Guatemala ; Honduras ; Mexico ; Nicaragua ; Panama
South America	Argentina ; Bolivia ; Brazil ; Chile ; Colombia ; Ecuador ; French Guiana ; Guyana ; Paraguay ; Peru ; Suriname ; Uruguay ; Venezuela, Bolivarian Rep. of

ASIA

Eastern Asia	China ; Hong Kong, China ; Japan ; Korea, Dem. People's Rep. of ; Korea, Republic of ; Macau, China ; Mongolia
South-Central Asia	Afghanistan ; Bangladesh ; Bhutan ; India ; Iran, Islamic Rep. of ; Kazakhstan ; Kyrgyzstan ; Maldives ; Nepal ; Pakistan ; Sri Lanka ; Tajikistan ; Turkmenistan ; Uzbekistan
South-Eastern Asia	Brunei Darussalam ; Cambodia ; Indonesia ; Lao People's Dem. Rep. ; Malaysia ; Myanmar ; Philippines ; Singapore ; Thailand ; Timor-Leste ; Viet Nam
Western Asia	Armenia ; Azerbaijan ; Bahrain ; Cyprus ; Georgia ; Iraq ; Israel ; Jordan ; Kuwait ; Lebanon ; Oman ; Qatar ; Saudi Arabia ; Syrian Arab Republic ; Turkey ; United Arab Emirates ; West Bank and Gaza Strip ; Yemen, Republic of

EUROPE

Eastern Europe	Belarus ; Bulgaria ; Czech Republic ; Hungary ; Moldova, Republic of ; Poland ; Romania ; Russian Federation ; Slovakia ; Ukraine
Northern Europe	Channel Islands ; Denmark ; Estonia ; Finland ; Iceland ; Ireland ; Latvia ; Lithuania ; Norway ; Sweden ; United Kingdom
Southern Europe	Albania ; Bosnia and Herzegovina ; Croatia ; Greece ; Italy ; Macedonia, The former Yugoslav Rep. of ; Malta ; Montenegro ; Portugal ; Serbia ; Slovenia ; Spain
Western Europe	Austria ; Belgium ; France ; Germany ; Luxembourg ; Netherlands ; Switzerland
OCEANIA	
Australia-New Zealand	Australia ; New Zealand
Melanesia	Fiji ; New Caledonia ; Papua New Guinea ; Solomon Islands ; Vanuatu
Micronesia	Guam
Polynesia	French Polynesia ; Samoa ; Tonga

ANNEX 2: Tables of regression specifications by region, sex and age group

Females											
1 Developed Europe											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared			x	x	x	x	x	x	x	x	x
Real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Lagged real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.852	0.833	0.838	0.870	0.913	0.926	0.927	0.946	0.950	0.934	0.864
2 Developed Non-Europe											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x	x	x	x	x	x	x	x	x
Real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Lagged real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.950	0.778	0.875	0.892	0.877	0.890	0.896	0.892	0.863	0.675	0.706
3 CEE and CIS											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x	x	x	x	x	x	x	x	x
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.573	0.536	0.627	0.615	0.661	0.733	0.804	0.856	0.765	0.824	0.868
4 East & South-East Asia (& the Pacific)											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x							x	x
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.913	0.887	0.940	0.955	0.957	0.943	0.936	0.921	0.938	0.959	0.951
5 South Asia											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP											
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 25-64	x	x	x	x	x	x	x	x	x	x	x
dummy	x	x	x	x	x	x	x	x	x	x	x
R-squared	0.928	0.969	0.967	0.961	0.965	0.958	0.948	0.936	0.943	0.886	0.807

Females											
6 Central America and the Caribbean											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 25-64	x	x	x	x	x	x	x	x	x	x	x
R-squared	0.849	0.873	0.934	0.927	0.929	0.931	0.931	0.913	0.894	0.920	0.928
7 South America											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 25-64	x	x	x	x	x	x	x	x	x	x	x
R-squared	0.879	0.907	0.909	0.919	0.905	0.897	0.896	0.900	0.905	0.883	0.928
8 Middle East & North Africa											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x	x	x	x	x	x	x	x	x
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.932	0.855	0.900	0.902	0.883	0.853	0.831	0.815	0.837	0.767	0.838
9 Sub-Saharan Africa											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP			x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.947	0.949	0.943	0.948	0.946	0.951	0.946	0.965	0.969	0.977	0.979

Males

1 Developed Europe

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x		x	x	x	x	x	x	x	x	x
Real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Lagged real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.859	0.706	0.736	0.561	0.634	0.484	0.687	0.740	0.898	0.935	0.894

2 Developed Non-Europe

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x	x	x	x	x	x	x	x	x
Real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Lagged real GDP growth rate	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.948	0.905	0.834	0.791	0.876	0.825	0.834	0.834	0.861	0.588	0.812

3 CEE and CIS

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared	x	x	x	x	x	x	x	x	x	x	x
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.589	0.614	0.623	0.502	0.431	0.447	0.462	0.444	0.774	0.835	0.857

4 East & South-East Asia (& the Pacific)

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared			x	x	x	x	x	x	x	x	x
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.931	0.802	0.848	0.845	0.869	0.872	0.863	0.848	0.831	0.938	0.978

5 South Asia

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Per-capita GDP											
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 25-64	x	x	x	x	x	x	x	x	x	x	x
dummy	x	x	x	x	x	x	x	x	x	x	x
R-squared	0.941	0.735	0.929	0.890	0.872	0.781	0.914	0.881	0.921	0.902	0.942

Males											
6 Central America and the Caribbean											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.889	0.742	0.668	0.722	0.704	0.720	0.754	0.777	0.792	0.899	0.955
7 South America											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x			x	x
Per-capita GDP squared		x	x	x	x						
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x							x	x		
Share of population aged 15-24	x							x	x		
Share of population aged 25-64	x							x	x		
R-squared	0.890	0.806	0.696	0.395	0.395	0.418	0.585	0.725	0.782	0.825	0.956
8 Middle East & North Africa											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP	x	x	x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14											
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.871	0.812	0.871	0.823	0.807	0.853	0.875	0.935	0.906	0.720	0.826
9 Sub-Saharan Africa											
	15-19	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Per-capita GDP			x	x	x	x	x	x	x	x	x
Per-capita GDP squared											
Real GDP growth rate											
Lagged real GDP growth rate											
Share of population aged 0-14	x	x	x	x	x	x	x	x	x	x	x
Share of population aged 15-24											
Share of population aged 25-64											
R-squared	0.920	0.825	0.802	0.822	0.790	0.813	0.820	0.863	0.915	0.966	0.970

Note: The dummy for South Asia equals 1 for the countries: Afghanistan, Bangladesh, Brunei Darussalam, Maldives, Pakistan.

ANNEX 3: Harmonizing LFPR by age bands

Very often, countries report data on labour force by age bands that are not identical to the 5-year age bands[26] used by the ILO. In addition, for the ILO the economically active population includes people aged 15 years and over, and in some countries this definition might differ. For example in the United States the economically active population is defined as 16 and over, while for Sweden it covers the population aged 16 to 74 years.

Two types of problems arise:

(i) The countries report data based on a different definition than 15 years and above (e.g., 16 and above).

(ii) The data reported by countries are available for age bands **larger** than 5 years (e.g., 35-44 instead of 35-39 and 40-44).

The techniques used to harmonise the data are described in the next paragraphs.

a. Harmonising data to 15 years and above

For the concerned countries, data need to be harmonised at the upper and lower age bands. The upper and lower age bands refer to the age group of 65 and over years and 15 to 19 years of age.

Lower age band adjustments (15-19 age band)

The countries for which the lower age limit adjustment is required include Iceland, Jamaica, Macau (China), Norway, Puerto Rico, Spain, Sweden, United Kingdom and United States. All the above countries have lower age limit of 16 years of age, except Jamaica and Macau (China), for which the limit is 14 years of age.

The basic assumption is that the labour force participation rate (LFPR) of 15 year olds for the above-mentioned countries is assumed to be proportional to the labour force participation rate of 16-19 years-old.

For the United States, more detailed data is available within the 16-19 years age band. Therefore, the US data is used to estimate the proportional coefficient (or ratio) that will be applied to all countries mentioned above.

Step 1: estimating the ratio for the US

For the US, estimates of the LFPR for 16-19 year olds are available for two sub-categories[27], 16-17 and 18-19. Since LFPRs within this age-group are positively related with age (the LFPR of 18-19 year olds is greater than 16-17 year olds), the assumption is that the same relationship holds for 15 year-olds to 16-17 year olds.

Therefore, the LFPR of the 15 year olds is estimated as using the proportional adjustment of equation [1]:

$$\widehat{LFPR^{US}_{s,y,15}} = \frac{LFPR^{US}_{s,y,16-17}}{LFPR^{US}_{s,y,16-19}} * LFPR^{US}_{s,y,16-17} \quad [1]$$

where s=male, female and y=1980, ..., 2009. For example in 2009, the LFPR of male of 15 year olds was estimated at 17.3%, resulting from:

$$\widehat{LFPR^{US}_{male,2009,15}} = \frac{25.53}{37.63} * 25.53 = 17.3$$

[26] More exactly the ten 5-year age groups (15-19,…,60-64) in addition to the 65+.

[27] The labour force participation rates for the United States come from the U.S. Bureau of Labor Statistics: http://www.bls.gov/data/.

Then, the ratio of the estimated LFPR of the 15 year olds to the LFPR of the 16 to 19 year olds is calculated:

$$USratio_{s,y} = \frac{\widehat{LFPR^{US}_{s,y,15}}}{LFPR^{US}_{s,y,16-19}}$$

[2]

In the example from above, the ratio for males 15 year olds was estimated at 46% in 2009, resulting from: 0.46 = 17.3 / 37.63

Step 2: estimating LFPR 15-19

For all the countries, the estimated LFPR for the 15 years-old is calculated by applying the US ratio estimated in equation [2] to the country LFPR of the 16-19 year olds:

$$\widehat{LFPR_{s,y,15}} = USratio_{s,y,} * LFPR_{s,y,16-19}$$

[3]

Hence, the estimated economically active persons aged 15 years is:

$$\widehat{LF_{s,y,15}} = \widehat{POP_{s,y,15}} * \widehat{LFPR_{s,y,15}}/100$$

[4]

In equation [4], the population aged 15 is derived from population data from the United Nations World Population Prospects' (*UN*) 15-19 population and the National Statistical Office's (*NSO*) 16-19 population.[28]

$$\widehat{POP_{s,y,15}} = POP^{UN}_{s,y,15-19} - POP^{NSO}_{s,y,16-19}$$

[5]

Then, the above estimated economically active population aged 15 year olds is simply added to the reported economically active population aged 16 to 19:

$$\widehat{LF_{s,y,15-19}} = \widehat{LF_{s,y,15}} + LF^{NSO}_{s,y,16-19}$$

[6]

Finally, the estimated LFPR for the lower age group of 15 to 19 year olds is:

$$\widehat{LFPR_{s,y,15-19}} = \frac{\widehat{LF_{s,y,15-19}}}{POP^{UN}_{s,y,15-19}} * 100$$

[7]

The LFPR for both sexes is derived from estimates of the labour force and the population for males and females. An example is provided in Table A1.

[28] UN, World Population Prospects 2010 revision database.

Table A1. Example of lower age adjustment: United Kingdom, 2009

			Country-reported data*			ILO Estimates				
	POP (UN, 15-19)	Ratio (US)	POP (NSO, 16-19)	LF (NSO, 16-19)	LFPR (NSO, 16-19)	EST POP 15	EST LFPR 15	EST LF 15	EST LF 15-19	EST LFPR 15-19
Female	1'938	0.460	1'541	766	**49.7**	397	23	91	*857*	***44.2***
Male	2'051	0.421	1'615	834	**51.6**	436	22	95	*928*	***45.3***
Both Sexes	3'989								*1'785*	***44.7***

Note: The country reported data come from OECD, Labour Force Statistics online database.

Note that the procedure differs for Norway. As of 2006 the age limit to participate in the Labour Force Survey (LFS) was lowered from 16 to 15 years. Therefore for 2006, data for both the LFPR (and LF) for 15-19 and 16-19 are available. Hence, we apply the ratio of LFPRs of 15-19 to 16-19 in 2006 retrospectively to the historical series 1980-2005.[29] The economically active persons aged 15 to 19 years and the LFPR for both sexes for the historical series 1980-2005 is calculated as above.

Adjustment of data from 14-19 to 15-19

For Macau (China), data are available by a 15-19 age band from 1992 to 1996 and in 2001 and 2002 (referred as sample 1). Data are available by a 14-19 age band for the years 1997, 1998, 2000 and 2004-2008 (referred as sample 2). The principle is here again to apply a proportional adjustment by assuming that the LFPR of 14 year olds is proportional to the LFPR of 15-19 years-old.

The proportion is estimated on the basis of the two observed samples:

$$ratio_{s,i} = \frac{\overline{LFPR}_{s,sample\ 2,14-19}}{\overline{LFPR}_{s,sample\ 1,15-19}} \quad [8]$$

The estimated economically active population aged 14 years is calculated using the same steps as described above. The same procedure has been used for adjusting data from Jamaica, except that due to the lack of any historical data for 15 to 19 year olds, the ratio has been set to 0.3, meaning that the LFPR of the 14 year olds is assumed to be almost one third of the LFPR of the whole age group 14 to 19 years.

Upper age band adjustments (65+)

The countries for which the upper age band has been adjusted are: Costa Rica, Estonia, Finland, Hungary, Iceland, Latvia, Norway, Romania and Sweden. For all the countries the upper age limit of the LFS is 74 years, except Costa Rica for which the upper age limit is 69 years.

The principle is to apply a proportional adjustment, assuming that the ratio of LFPR of 75+ to that of 70-74 year olds is the same as the ratio of the LFPR of 70-74 year olds to that of 65-69 year olds. The steps and the logic are identical to the lower age band adjustments. An example is provided in Table A2 for Sweden. For Romania, the only difference is that the population reported by the NSOs is used instead of the UN's.

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[29] The data come from Statistics Norway: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selecttable/MenuSelS.asp&SubjectCode=06.

Table A2. Example of upper age adjustment: Sweden, 2009

	Country-reported data*									ILO Estimates						
	65-69			70-74			65-74									
	LF	POP	LFPR	LF	POP	LFPR	LF	POP	LFPR	UN POP 65+	EST POP 75+	Ratio 70-74/65-69 LFPR	EST 75+ LFPR	EST 75+LF	EST 65+ LF	Adjusted 65+ LFPR
Female	33	252	**13.28**	8	196	**3.94**	41	447	**9.20**	933	*485*	0.30	*1.0*	*6*	*47*	***5.02***
Male	55	248	**21.97**	16	178	**8.74**	70	426	**16.45**	733	*307*	0.40	*3.1*	*11*	*81*	***11.02***
Both sexes										1’665					*128*	*7.66*

Note: The country reported data come from OECD, Labour Force Statistics online database.

2. Harmonising data from large age bands to 5-year age bands

For many countries, the LFPRs reported by the National Statistical Offices are frequently not broken down by the standard 5 years age groups. For example, in Puerto Rico apart from the tails of the age distribution, the country reports LFPRs for the population aged between 25 and 34 years, between 35 and 44 years, between 45 and 55 years, and between 55 and 64 year olds.

The principle is to break down reported data by large-band (eg. 10 years) using a proxy variable, for which data is available by 5-year age bands. This consists of two steps.

Step 1: First estimate based on proxy variable.

Step 2: Adjust the estimate in order to match the original data.

Two types of proxy variables have been used. The best proxy variable to use is LFPRs from other years in which data are available by 5-years age bands from national sources. For example, in Puerto Rico complete data by 5-year age bands are available in 2000 and can be used to derive estimates for the years that follow.

The second best proxy variable used here is the regional or sub-regional central values of LFPRs by 5-year age bands, calculated using the median. When available, the sub-regional medians are used. However, for some sub-regions such as Central or North Africa there is not always enough information to derive reliable central values. In that case, the regional medians are used.

Formally, the first step consists of computing differences at the large band level *A*:

$$DIFF_{A,t} = LFPR_{A,t} - Proxy_{A,t} \qquad [9]$$

where LFPR is a gender specific LFPR (male or female) and *t* the corresponding year.

Most of the time, the large age band *A* is 10-years wide. Let us note *a1* and *a2*, the two 5-year wide age groups that fall into the larger age band *A*.

In identity equation [1], $Proxy_{A,t}$ has been computed as:

$$Proxy_{A,t} = \omega_{a1,t} * Proxy_{a1,t} + (1 - \omega_{a1,t}) * Proxy_{a2,t} \qquad [10]$$

where $\omega_{a1,t}$ represents the proportion of the population of the age band *a1* in the age band *A*. The weight $\omega_{a1,t}$ is derived from national data or from UN population estimates when national data are not available.

The first estimates are then computed:

$$LFPR'_{a1,t} = Proxy_{a1,t} + DIFF_{A,t}$$

and

$$LFPR'_{a2,t} = Proxy_{a2,t} + DIFF_{A,t} \quad [11]$$

By construction, these estimates respect the following condition:

$$LFPR'_{A,t} = LFPR_{A,t}$$

Further adjustments can be done if the proxy is not judged to be very reliable. This can result in out of range estimates (>100% or < 0%) or more frequently unexpected results for estimates that belong to different large age-groups, for example LFPR'[60-65] (based on [60+] data) that exceeds LFPR'[55-59] (derived from [50-59] reported data).

See the example of Rwanda, highlighted in Charts 1 and 2. Data for 2001 was reported for four age-bands: 15-24, 25-34, 35-54 and 55-64. In the case of male participation rates, the first estimate gives results that seem meaningful. For female participation rates, the first estimate gives inconsistent results for the [55-59] age band as compared to the [50-54] age group. Therefore a correction has been applied, resulting in final estimates that look much more coherent.

The corrective adjustments simply rely on combining the first estimate and the original data. Formally, the following formula is used:

$$LFPR''_{a1,t} = \lambda * LFPR'_{a1,t} + (1-\lambda) * LFPR_{A,t} \quad [12]$$

Different values of λ are tested, λ reflecting the weight attributed to the first estimate. First λ=0.5, then if the estimate is still inconsistent, λ=0.25 and if finally λ=0. In the later case, the final estimate is set to the original data.

The final estimate is then obtained by calculating the discrepancies between these second estimates and the original data and allocating them at the 5-year age band level, such as in formulas [5] and [6].

$$DISCREPANCY_{A,t} = LFPR''_{A,t} - LFPR_{A,t} \quad [13]$$

where

$$LFPR''_{A,t} = \omega_{a1,t} * LFPR''_{a1,t} + (1-\omega_{a1,t}) * LFPR''_{a2,t}$$

Then the discrepancy is allocated within each 5-year age band, for example for age band *a1*:

$$FINAL\ LFPR_{a1,t} = LFPR''_{a1,t} + DISCREPANCY_{A,t} \quad [14]$$

During this exercise, the first estimate was judged as adequate in around 85% of the cases (2'400 records out of 2'800). There was a need to use the original data (λ=0) for only 9 records out of 2'800.

Chart 1: Male LFPR in Rwanda 2001, results of age-split adjustments

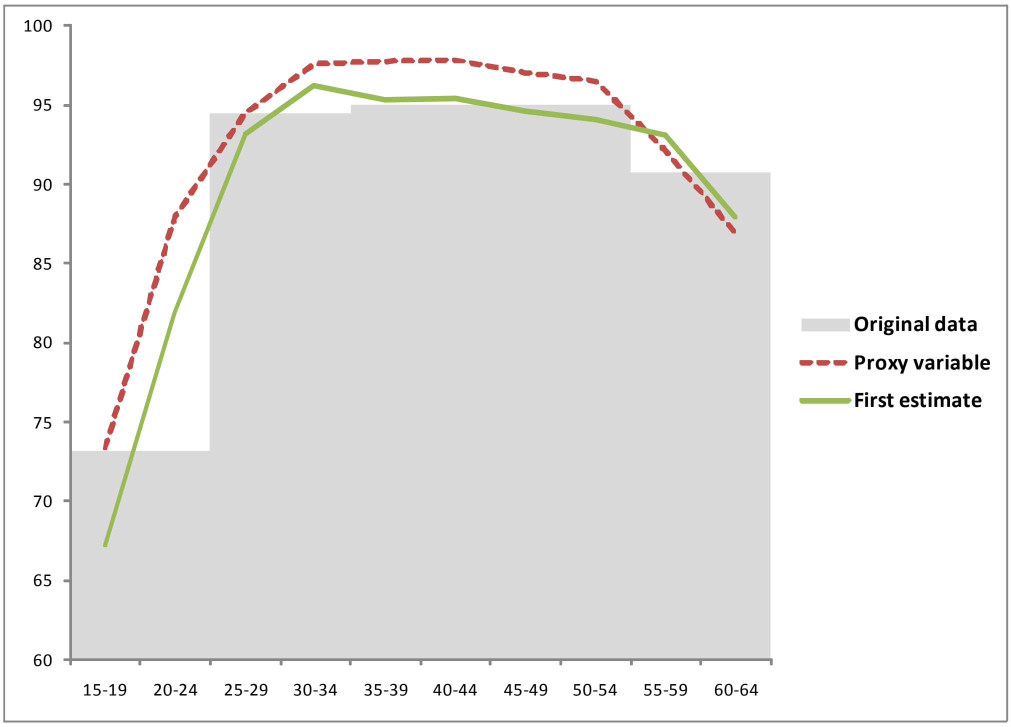
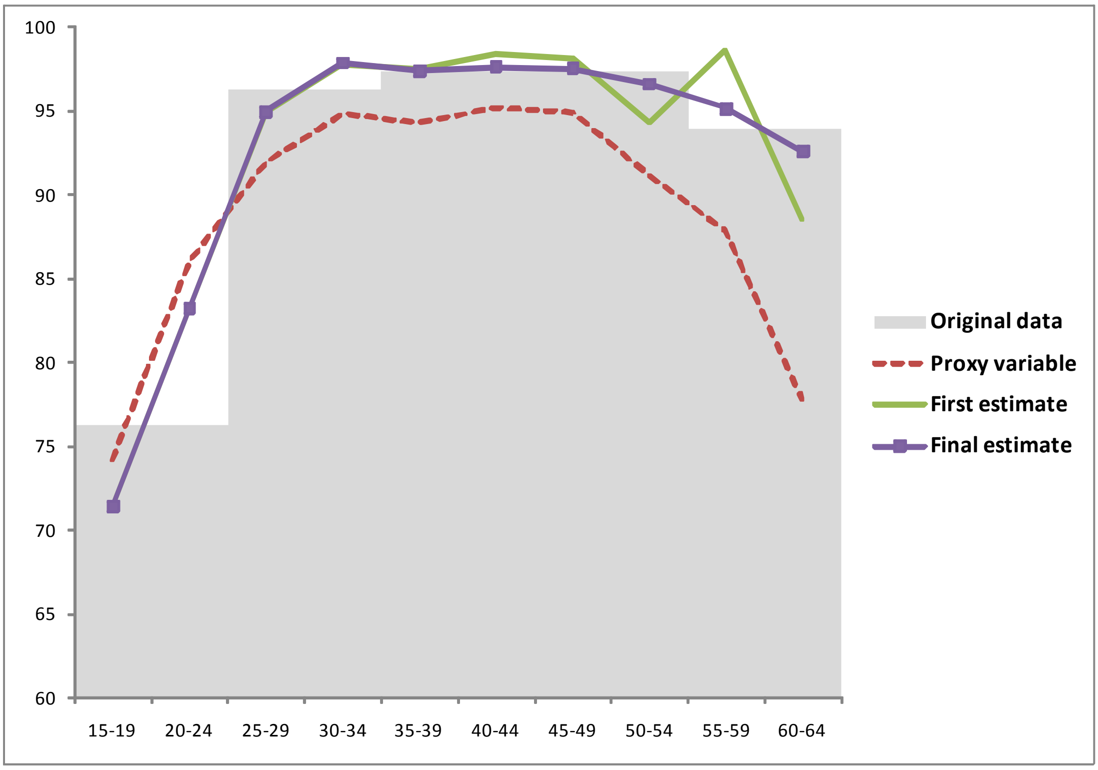


Chart 1: Female LFPR in Rwanda 2001, results of age-split adjustments



ANNEX 4: Adjustments of LFPR data derived from urban surveys

For several countries, predominantly in Latin America, households (or labour force) surveys do not always cover the entire territory and are restricted to urban areas. Cases in point are Uruguay and Argentina.

For those countries, alternative adjustments can be undertaken with a high degree of accuracy provided that two conditions are met. Firstly, household surveys covering the entire territory are available for at least one year and secondly, the urban areas cover a significant share (e.g., 30%) of the total population.

The principle is to apply a proportional adjustment and to estimate the national participation on the basis on participation rates for urban areas, on the basis of the following relation:

$$LFPR[total]_{a,s,t} = \varpi . LFPR[urban]a,s,t \quad + \; (1-\varpi). LFPR[rural]_{a,s,t} \qquad \text{[a1]}$$

where ω represents the ratio of urban-to-total population. Symbols *a*, *s* and *t* represents respectively the age group, the sex and the year. If for a given year *T*, both urban and rural data are available, then the ratio of urban to rural ratio can be computed:

$$\alpha_{a,s,T} = \frac{LFPR[rural]_{a,s,T}}{LFPR[urban]_{a,s,T}} \qquad \text{[a2]}$$

Usually, this ratio is superior to one. In other words, the LFPR is higher in rural areas than in urban ones. However, this ratio differs differ considerably across countries, due to differences in agrarian structures and land concentration.

The estimate is given by the following formula:

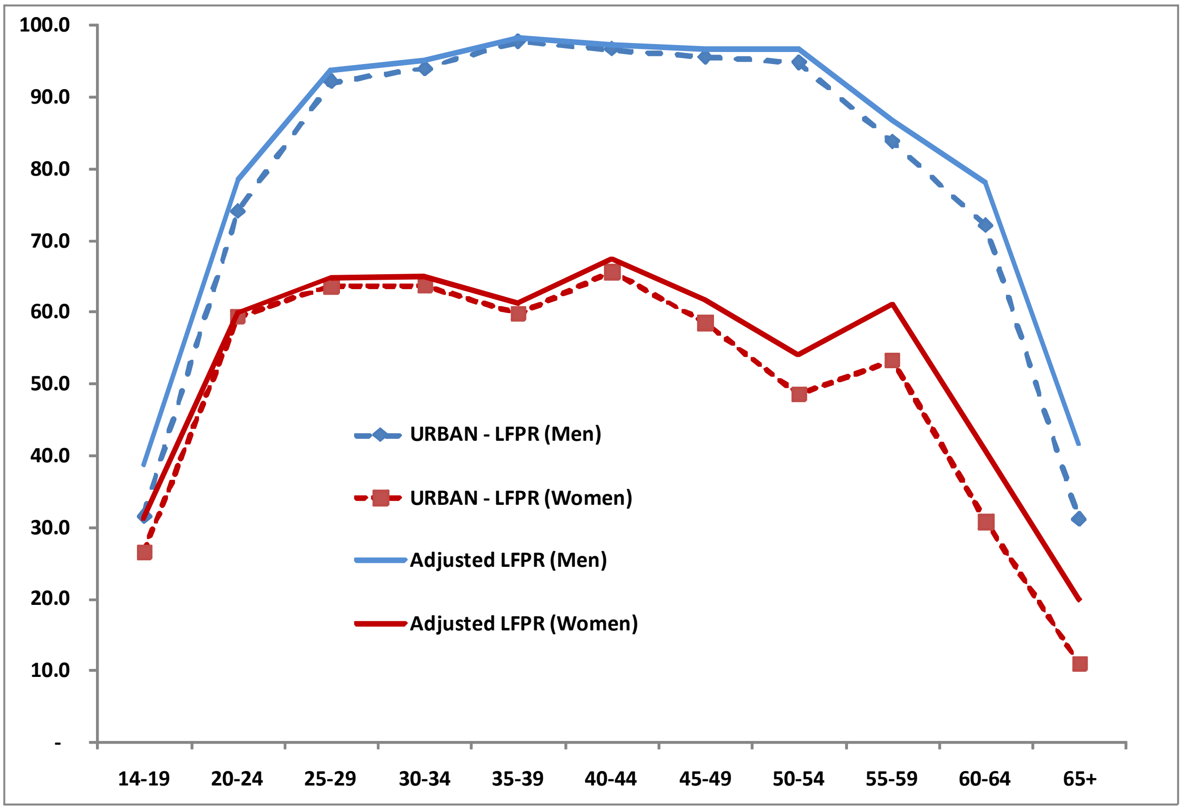
$$PR[total]'_{a,s,t} = PR[urban]_{a,s,t} * (\varpi + (1-\varpi) * \alpha_{a,s,T}) \qquad \text{[a3]}$$

The quality of this estimate depends on the value ω (ratio of urban-to-total population) and the volatility of $\alpha_{a,s,T}$ over time. For example, the value of ω is close to 84% for Uruguay, while it is closer to 30% for Peru (Metropolitan Lima), making the adjustment more accurate for Uruguay.

In this edition, the adjustments have been made for Argentina, Bolivia, Peru and Uruguay, on the basis of rural and urban estimates at 5 year intervals (1990, 1995, ..., 2010) published by CELADE in 2006.

Figure 9 highlights the differences between reported urban LFPR and adjusted ones for Peru. The differences between the two curves are significant for both sexes.

Figure 9: Labour Force Participation rates in Peru (2005, LFS).



Note: Urban data covers Metropolitan Lima.

ANNEX 5: Results from ex-ante simulations

The exercise consists of comparing "ex-ante" (before the action) projections from different models and to those made by National Statistics Organisations (NSO).

The twelve countries that are covered are displayed in the list below:

Country	Source of projections (NSO)
Australia	Australian Government Productivity Group
Austria	STATISTICS AUSTRIA
France	INSEE
Germany	Institute for Employment Research (IAB)
Hong Kong, China	Hong Kong Statistics Office
Ireland	Central Statistics Office
Mexico	Conapo, Consejo Nacional de Poblacion
Slovakia	Demographic Research Centre, Infostat
Sweden	Statistiska centralbyrån
Switzerland	Office fédéral de la Statistique, Section Travail et vie active
United Kingdom	Office for National Statistics
United States	Bureau of Labor Statistics

The tables that follow display the average absolute discrepancy (expressed in percentage points of participation rate) between the projections published by the NSO and the projections obtained from each of the six models. The results are averaged over the twelve countries. For each line, the cell displaying the lowest value is in shaded. In other words, shaded cells highlight the method that gives the closest projections to that of the NSO.

It is worth mentioning that the most accurate method is unknown, since projections made by NSOs are also subject to prediction errors.

Table A3: Average absolute discrepancy for male LFPR

age group	1. Panel model	2. Pre-crisis level	3. Constrained trend (narrow range)	4. Constrained trend (wide range)	5. Constrained trend, large age-band	6. Trend+Cycle
15-19	3.5	2.8	2.7	3.1	3.9	3.7
20-24	4.0	3.3	2.1	2.2	5.9	2.4
25-29	0.8	1.1	0.9	1.0	1.4	1.3
30-34	0.9	0.6	0.7	0.8	1.3	0.8
35-39	0.5	0.7	0.6	0.6	1.2	0.8
40-44	1.4	0.6	0.9	0.9	1.5	1.5
45-49	1.2	0.7	1.0	1.1	1.3	1.4
50-54	1.1	0.7	1.1	1.2	1.4	1.4
55-59	2.2	3.6	2.1	2.3	7.4	2.3
60-64	5.7	7.5	3.9	4.1	5.3	5.5
65+	2.5	2.4	2.3	2.4	1.4	3.3

Table A4: Average absolute discrepancy for female LFPR

Age group	1. Panel model	2. Pre-crisis level	3. Constrained trend (narrow range)	4. Constrained trend (wide range)	5. Constrained trend, large age-band	6. Trend+Cycle
15-19	3.5	2.7	2.0	2.3	2.7	3.3
20-24	3.7	3.0	2.6	2.7	5.0	3.9
25-29	2.4	2.4	1.8	1.9	2.4	2.5
30-34	2.6	4.2	2.0	2.3	2.1	2.8
35-39	2.7	4.2	1.8	2.0	1.7	2.5
40-44	2.1	3.6	1.2	1.5	1.2	1.7
45-49	2.2	3.9	2.0	2.2	1.3	2.5
50-54	3.1	5.5	2.1	2.4	1.2	2.6
55-59	5.4	9.7	2.1	2.8	6.8	2.1
60-64	3.7	9.4	3.7	4.2	3.3	4.4
65+	1.1	2.0	1.2	1.1	0.8	1.6

ANNEX 6: Results from ex-post simulations

The principle of *ex-post* (after the action) experiments consists of dropping the last observations of a time series, then deriving projections on the basis of the shortened time series and calculating and analysing the ex-post (also called "post-sample") error projections.

The sample includes 22 countries for which consistent historical data are available from 1985 to 2009. The countries include: Australia, Austria, Belgium, Canada, Costa Rica*, Denmark, Finland, France, Germany, Greece*, Hong Kong* (China), Ireland, Italy*, Japan, Korea Republic of*, Luxembourg, Norway, Portugal*, Spain*, Sweden, United Kingdom and United States. The seven countries that are followed by an "*" are part of a subsample of former developing and Southern European countries, for which the computations are presented separately.

Tables A5 and A6 display the average absolute projection errors (expressed in percentage points of participation rate) at the horizon of ten years. The results are averaged over five projection exercises with the following projection origins: 1995, 1996, 1997, 1998 and 1999. For each line, the cell displaying the lowest value is shaded. In other words, shaded cells highlight the most accurate method for each age band.

The methods are not exactly the same as those tested during the ex-ante experiment. The "Trend+Cycle" and the Panel Model could not have been replicated retroactively since they would needed old GDP and population forecasts made more than 15 years ago.

The main findings are the following:

(i) As expected, female LFPRs are more difficult to predict than male LFPRs. For both male and female LFPRs, the most delicate age bands to predict are seniors (55+) and young workers (15-24).

(ii) In the prime age (25-54), while female LFPRs are complex to project, male LFPRs display strong inertia over time. The naive method performs very well for male LFPRs in the prime age (25-54), with an average absolute error of around 1 percentage point.

(iii) There are significant gains in accuracy when restrictions on the trends are added. In most cases, the linear trends with a constraint on the range (narrow or wide) perform better both than the linear trend (0-1 range) and the logistic trend (non-linear estimation).

(iv) In general, combining improves projection accuracy. The gains are obvious for projections of male LFPRs. For female LFPRs, the tested combinations did not perform as well.

(v) For female LFPRs, the constrained trend computed at the large age band level is in general the most accurate projection method. Except for the 20-24 age groups, the naive method performs poorly for female LFPRs, since trends are more persistent than for male LFPRs.

Table A5: Average absolute projection errors for male LFPR

Age group	(A) Naive	(B) Trend with [0-1] range	(C) Trend with LARGE range	(D) LOGISTIC trend (Unconstrained)	(E) Trend with NARROW range	(F) Trend computed at the LARGE age band level	(G) Combination (E+F)	(H) Combination (average A+E)
	SAMPLE 1: MALE PR, all countries							
15-19	5.3	7.1	5.5	8.9	5.2	4.4	4.7	4.4
20-24	4.6	10.6	5.5	8.6	5.1	6.0	4.8	4.3
25-29	1.8	4.5	2.2	3.5	2.0	1.7	1.8	1.2
30-34	1.2	3.8	1.5	1.9	1.4	1.2	1.2	0.9
35-39	1.1	3.8	1.4	4.9	1.3	1.1	1.1	0.7
40-44	1.1	4.6	1.3	2.9	1.3	1.1	1.1	1.0
45-49	1.1	3.0	1.4	1.9	1.3	1.2	1.2	0.9
50-54	1.9	4.4	2.9	3.2	2.8	2.4	2.5	1.6
55-59	4.4	9.9	7.6	10.5	7.1	7.3	6.6	5.4
60-64	6.6	12.3	10.6	16.1	9.8	7.7	8.6	7.9
65+	2.4	3.2	3.0	7.1	2.9	2.1	2.4	2.3
AVERAGE 15+	**2.9**	**6.1**	**3.9**	**6.3**	**3.7**	**3.3**	**3.3**	**2.8**

Age group	(A) Naive	(B) Trend with [0-1] range	(C) Trend with LARGE range	(D) LOGISTIC trend (Unconstrained)	(E) Trend with NARROW range	(F) Trend computed at the LARGE age band level	(G) Combination (E+F)	(H) Combination (average A+E)
	SAMPLE 2: MALE PR, sub sample of countries							
15-19	5.6	4.3	2.0	6.2	2.5	2.9	2.6	3.8
20-24	7.6	11.8	5.7	10.0	5.7	6.5	5.3	6.4
25-29	2.9	6.7	2.6	10.5	2.5	2.5	2.4	2.5
30-34	1.7	3.3	1.8	1.5	1.8	1.1	1.4	1.6
35-39	1.2	1.2	1.0	4.2	1.0	0.5	0.6	1.1
40-44	1.3	1.2	1.3	1.5	1.3	0.6	0.8	1.3
45-49	1.0	2.1	1.6	0.7	1.5	1.0	1.1	1.2
50-54	2.6	5.4	3.4	4.4	3.2	2.8	2.8	2.8
55-59	2.7	6.9	5.3	4.3	4.9	9.8	6.9	3.5
60-64	3.1	8.2	6.1	9.3	5.2	6.9	5.9	3.3
65+	2.1	2.7	2.1	5.5	2.1	1.3	1.7	2.1
AVERAGE 15+	**2.9**	**4.9**	**3.0**	**5.3**	**2.9**	**3.3**	**2.9**	**2.7**

Table A6: Average absolute projection errors for female LFPR

	SAMPLE 3: FEMALE PR, all countries							
Age group	(A) Naive	(B) Trend with [0-1] range	(C) Trend with LARGE range	(D) LOGISTIC trend (Unconstrained)	(E) Trend with NARROW range	(F) Trend computed at the LARGE age band level	(G) Combination (E+F)	(H) Combination (average A+E)
15-19	5.2	7.6	6.4	6.3	6.1	4.8	5.3	5.5
20-24	4.4	9.2	6.3	14.3	6.0	6.2	5.5	5.2
25-29	5.5	5.7	4.3	10.8	4.5	5.1	3.8	4.4
30-34	6.3	5.0	5.0	14.0	5.2	2.9	3.2	4.8
35-39	6.5	4.5	5.2	11.0	5.4	2.7	3.2	4.7
40-44	6.7	4.5	5.7	10.7	5.9	2.5	3.7	5.0
45-49	9.4	4.2	7.9	11.3	8.2	4.1	5.9	7.1
50-54	11.4	6.3	9.3	12.5	9.7	6.6	8.0	8.9
55-59	12.5	9.9	10.7	16.6	10.9	7.6	8.9	11.2
60-64	8.3	8.4	8.7	12.3	8.7	5.6	7.0	8.5
65+	1.4	1.9	1.5	5.2	1.5	1.0	1.2	1.4
AVERAGE 15+	**7.1**	**6.1**	**6.5**	**11.4**	**6.6**	**4.5**	**5.1**	**6.1**

	SAMPLE 4: FEMALE PR, sub sample of countries							
Age group	(A) Naive	(B) Trend with [0-1] range	(C) Trend with LARGE range	(D) LOGISTIC trend (Unconstrained)	(E) Trend with NARROW range	(F) Trend computed at the LARGE age band level	(G) Combination (E+F)	(H) Combination (average A+E)
15-19	5.8	3.5	2.1	5.2	2.8	3.9	3.3	4.0
20-24	5.6	8.2	6.5	16.6	6.4	6.3	5.6	6.0
25-29	8.4	2.9	5.9	9.5	6.3	6.1	4.0	6.1
30-34	8.5	2.2	6.3	16.6	6.7	1.7	3.1	6.0
35-39	9.0	6.0	7.9	17.6	8.1	3.6	5.1	7.3
40-44	9.7	6.8	8.9	11.9	9.1	3.5	6.0	8.1
45-49	12.4	6.4	10.9	14.6	11.1	5.6	8.2	10.2
50-54	13.2	9.1	12.1	8.5	12.4	8.1	10.2	11.7
55-59	9.9	11.1	10.9	9.8	10.7	9.6	10.1	10.5
60-64	4.4	6.2	6.4	6.3	6.1	4.4	5.2	5.6
65+	1.4	2.5	1.0	12.5	1.1	0.9	0.8	1.1
AVERAGE 15+	**8.0**	**5.9**	**7.2**	**11.7**	**7.3**	**4.9**	**5.6**	**7.0**