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EUROSTAT
Directorate C: National Accounts, Prices and Key Indicators
DG JOINT RESEARCH CENTRE
Directorate B. Growth and Innovation

Methodological document on labour productivity indicators for the EU-28: quality adjusted labour input

Quality adjusted labour input (QALI) is a project involving the Joint Research Centre and Eurostat that was carried out between 2014 and 2016. The project aims to calculate QALI indicators for the EU-28, EA-19 and for EU Member States individually.

Abstract

This document describes the methodology for estimating the growth of labour input, with a distinction made between the hours worked and the quality of the workforce based on experience (estimated by using the age of the worker as a proxy for work experience) and skills (estimated by using the highest academic qualification attained according to the International Standard Classification of Education).

Three main tasks were performed:

- survey microdata were scaled to national accounts data: hours worked (HW) and compensation of employees (D1);
- survey microdata relating to hours worked and earnings for 2002-2007 were converted from NACE[1] Rev.1.1 to NACE Rev.2 A*10 using specific bridge matrices for each country and year;
- survey microdata for earnings were adjusted to avoid inconsistencies between surveys (Labour Force Survey, Structure of Earnings Survey and EU-Statistics on Income and Living Conditions).

QALI was therefore calculated from 2003 to 2014 for each EU Member State; EU-28 and EA-19 and was weighted by skills, by age and by combinations of skills and age groups respectively.

The industry breakdown varies across countries due to the reliability/confidentiality constraints of the survey data: 21 industries (A*21) are therefore only available for six countries[2], the EU-28 and EA-19; however, 10 industries (A*10) and the total economy are available for all countries, the EU-28 and EA-19.

[1] Statistical classification of economic activities. For detailed definition: http://ec.europa.eu/eurostat/statistics-explained/index.php/NACE_background

[2] France, Germany, Italy, the Netherlands, Spain, United Kingdom.

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Background

Multifactor productivity measurement helps identify the direct growth contributions of labour, capital, intermediate inputs and multifactor productivity change. For labour in particular, the following is known from the System of National Accounts 2008[3]:

'19.55 Using total hours actually worked as the input measure for calculating labour productivity changes over time implicitly assumes that each hour worked is of the same quality (that is, there are no differences in the qualifications and skill levels of the labour employed). In other words, each hour worked by a highly skilled person, such as a brain surgeon, is assumed to produce the same quantity and quality of output as each hour worked by an unskilled worker. It is possible to produce a quality adjusted measure of the labour inputs that takes account of changes in the mix of workers over time by weighting together indicators of quality for different grades of workers. […].

19.56 The quality indicators used can relate to variables such as academic qualifications, trade qualifications, experience (typically based on age of the worker), industry of employment and so on. The various indicators are weighted together using average hourly wages for a worker falling into each category. The premise behind this approach is that workers are hired only until their marginal price (that is, their wages, including on-costs) is less than the marginal revenue expected to result from their production. […].'

QALI measures labour input to economic production, taking into account the different composition of the workforce as well as the number of hours worked. Such an approach provides a more accurate picture of the input of labour to the production process as opposed to traditional measures, which focus only on the quantity of labour input (e.g. employment). The QALI index therefore provides a broader perspective for assessing productivity performance. It is also a more suitable method to use in productivity and growth accounting analyses as it explains GDP developments better.

Törnqvist index

To derive QALI indicators, the available literature (OECD, 2001) generally draws on the Törnqvist index.

The number of hours worked is divided into n groups (e.g. high, medium and low skilled labour, age groups, gender). The growth in quality adjusted hours for a period (t) compared to the previous one can be represented using a Törnqvist index — typically defined as a weighted geometric average of growth rates of hours worked (h), where the weights are labour income shares (w) across the different groups (i) and $e_{i,t}$ represents earnings across different groups (i) (Törnqvist, 1936).

$$Q_{t-1}^{t} = \prod_i \left(\frac{h_{i,t}}{h_{i,t-1}}\right)^{\left(\frac{w_{i,t}+w_{i,t-1}}{2}\right)} \qquad w_{i,t} = \frac{e_{i,t}}{\sum_i e_{i,t}} \quad (1)$$

Income shares are used here as a proxy for productivity for the weights based on the neoclassical assumption that workers are paid at their marginal productivity.

[3] The System of National Accounts 2008 (2008 SNA) is the latest version of the international statistical standard for national accounts, adopted by the United Nations Statistical Commission.

QALIs are indexes with base on the previous year: $Q^{t}_{t-1} = Q_t \ \forall$t=2003,…,2015. Chained QALIs are indexes linking annual indexes multiplicatively with base on the year 2010 for comparison purposes: $ChQ^{t}_{2001} = Q_t \ \forall$t=2002,⋯,2015. By definition, $chQ^{2010}_{2010} = Q^{2010}_{2010} = 1$ and:

$$ChQ^{t}_{2010} = ChQ_t = \begin{cases} \prod_{p=2011}^{t} Q^{p}_{p-1} & t > 2010 \\ 1 & t = 2010 \\ \left(\prod_{p=t+1}^{2010} Q^{p}_{p-1}\right)^{-1} & t < 2010 \end{cases} \quad (2)$$

Worker quality groups

The qualities for dividing the workforce into groups to assess productivity performances are as follows:

Table 1. Summary of qualities of labour

Age[4]	*Skill*[5]
15-29	High (ISCED97= 0-2)
30-49	Medium (ISCED97= 3-4)
50+	Low (ISCED97= 5-6)

Data

Two types of data sources are used to calculate QALI: microdata (surveys) and macrodata (aggregates). Table 2 contains the variables considered from each source.

[4] As a proxy for work experience.

[5] Workers are classified according to International Standard Classification of Education (ISCED 1997) of UNESCO.

Table 2. Description of the variables

	LFS	SES	EU-SILC	NA ESA2010[6]
Country of residence	COUNTRY	-	PB020	-
Year	YEAR	YEAR	PB01	TIME
Country of work	COUNTRYW	COUNTRY	-	GEO
Industry ***(NACE Rev.1.1)*** ***(NACE Rev.2)***	NACE2D	A13	PL110 PL111	NACE_R1 NACE_R2
Skill levels	HATLEV1D	B25	PE040	-
Age	AGE (based in YEARBIR)	(derived from B22)	(derived from PX020)	-
Annual hours worked[7][8][9] ***Before t*** ***From t***	HWUSUAL	B34*B321/4.35 B32*B31/4.35	RES_WGT * PL060 * 4.35 * (PL070 +PL072) RES_WGT * PL060 * 4.35 * (PL073 + (0.5 * PL074) + PL075 + (0.5 * PL076))	HW
Annual earnings[10] ***Before t*** ***From t***	-	B32 B41	RES_WGT* (PY010C + PY020C + PY050C)	D1

[6] Tables: [nama_10_a10] for *compensation of employees* and [nama_10_a10_e] for *hours worked.*

[7] T=2002 for SES, t=2009 for EU-SILC.

[8] RES_WGT = PB040 or PB060 depending on the cases (PB060 used when countries use selected respondent sampling frame).

[9] 4.35 is the average number of weeks within a month (365 days per year / 7 days per week / 12 months per year).

[10] Before 2007, gross income data (G) collection was not mandatory in EU-SILC; net income (N) could be collected instead. In such cases, net values are used in calculations (C) using, instead of gross values, PY010C = PY010G or PY010N, PY020G = PY020G or PY020N and PY030C = PY030G or PY030N depending on data availability.

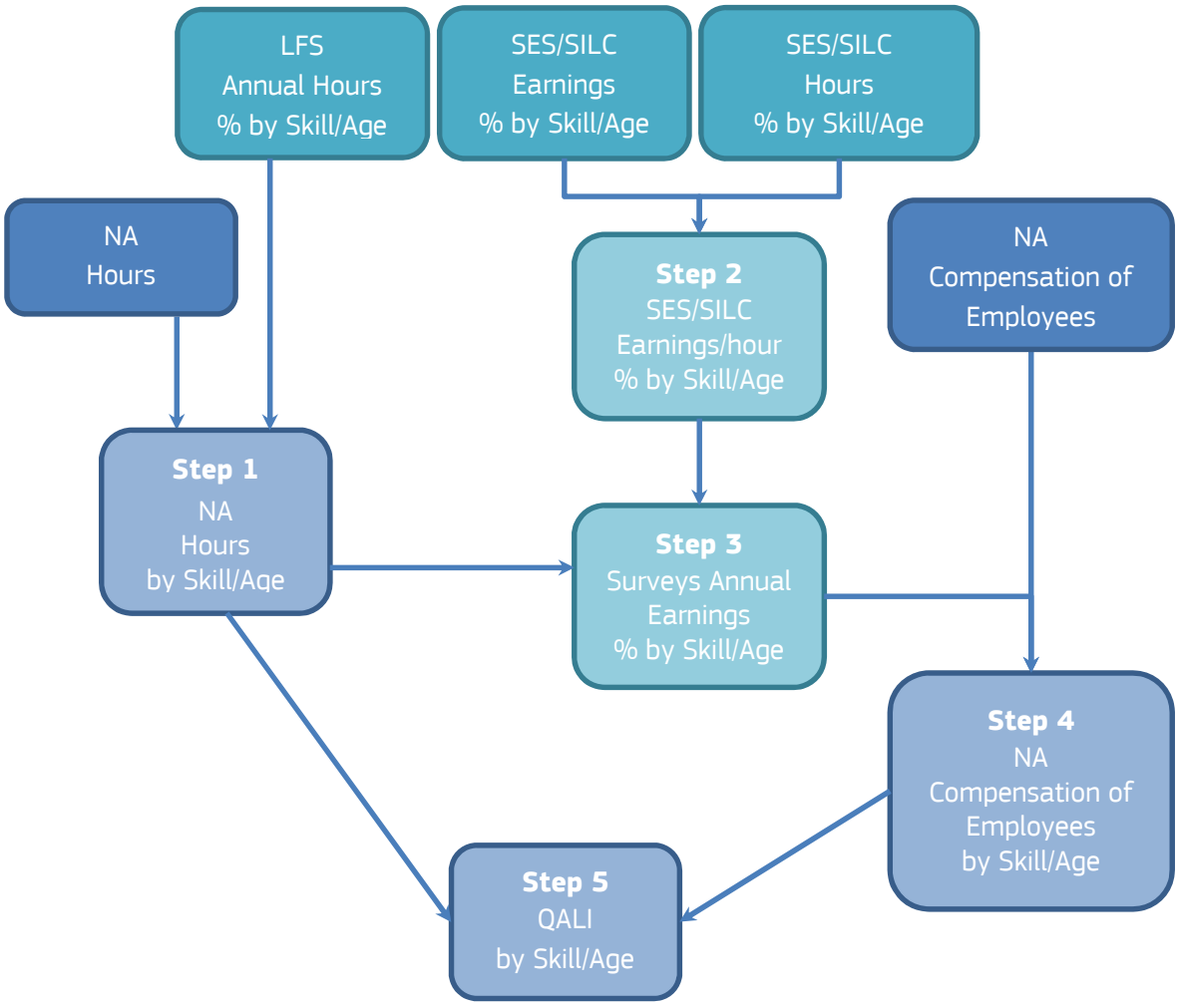
Data processing and scaling

QALI is calculated for all Member States and all industries (A*10 and A*21, depending on the availability of microdata).

In practice, the main steps involved in compiling QALI indicators are as follows:

1. The structure of hours worked from LFS by age and skill is applied to national accounts totals ($HW_{i,t}$[11]).
2. Earnings per hour are calculated from SILC or SES ($eh_{i,t}$).
3. Earnings per hour from step 2 are multiplied by the hours worked from step 1 to calculate annual earnings: $e_{i,t} = eh_{i,t} \text{ X } HW_{i,t.}$
4. The earnings from step 3 are scaled to the national accounts totals (D1) into different age groups and skill levels.
5. QALI and chained QALI are calculated using hours worked from step 1 and annual earnings from step 4 (See formulas (1) and (2) described on pages 3 and 4).

Figure 1: Data processing and estimation



[11] i represents groups of age and skills, and t represents years.

Tasks undertaken before data processing

- missing hours worked from national accounts were estimated using a bottom-up approach or top-down approach (whenever the sections were the same in A*10 and A*21) and homogenised across different vintages of data;
- geometric interpolation (constant growth rate) of earnings structure data was performed whenever the SES was not available as SES waves are created every 4 years;
- data were converted from NACE Rev.1.1 to NACE Rev.2 using bridge matrices from the breakdowns A17 to A*10/A*21;
- homogenisation of EU-SILC/SES data: earnings for primary (agriculture, forestry, fishing) industries were estimated using the EU-SILC survey data and made consistent with SES standards.

  Following calculations, the reliability of the results were checked as follows:

  - for the breakdown by 10 industries (A*10): by using only skill and age qualities together, more than 60 % of the quality adjusted measures must be hidden (extremely unreliable) or flagged as unreliable, or around 25 % for skill levels only;
  - for the A*21 breakdown: at Member State level, the reliability and confidentiality of the data were assured for six Member States only (FR, DE, NL, ES, IT, UK) when considering the skill split alone, and for 12 Member States (the six aforementioned and AT, BE, CZ, PL, SI, SE) when considering the age split alone.

Flagging

To inform users about data gaps and limitations, results were flagged with several sets of flags (see Table 3):

- internal flags (Box A)
- external flags on data (Box B)
- external flags on QALI (Box C).

The purpose of the internal flags is to specify the reasons for the unavailability/unreliability etc. of source data, i.e. mainly related to the confidentiality of microdata used as inputs.

The purpose of the external flags is the usability of the 'intermediate data' calculated (hours and earnings) and used as input data in formula (1).

Note that the flags for QALI and chained QALI are not necessarily the same — for flagging chained QALI, the flags of all links involved (QALI between t and t_0 or vice versa) would need to be taken into account into a specific set of flags for chained QALI.

Table 3. Set of flags

A. Internal flags

Flag	Condition data sheets		Comments
	NACE2	NACE1	
isLfsVeryUnr	LFS workers of any category of a specific industry-country-year < Limit A[12]	LFS workers of any category of any contributing (bridge matrix coeff>0) industry-country-year < Limit A	Reliability limits not available for some countries in the most recent year
isLfsUnr	Limit A < LFS workers of any category of a specific industry-country-year < Limit B[11]	Limit A < LFS workers of any category of any contributing (bridge matrix coeff>0) industry-country-year < Limit B	if isLfsVeryUnr == TRUE, then isLfsUnr == TRUE
isLfsConf	LFS frequency of a specific category of a specific industry-country-year ≤ 3	LFS frequency of a specific category of the main contributing industry-country-year ≤ 3	
isSilcUnr	20 ≤ SILC frequency of any specific category of a specific industry-country-year < 50	20 ≤ SILC frequency of any specific category of a specific industry-country-year < 50	
isSilcConf	SILC input data of a specific category of a specific industry-country-year is flagged as confidential	SILC input data of a specific category of a specific industry-country-year is flagged as confidential	
isSilcNA	The entry in the SILC dataset of a specific category of a specific industry-country-year = 0	The entry in the SILC dataset of a specific category of a specific industry-country-year = 0	
isSesConf	SES input data of any specific category of a given industry-country-year is flagged as confidential	SES input data of a specific category of the main contributing industry-country-year is flagged as confidential	
isSesNA	Inter-survey year or missing entry in the SES dataset	Inter-survey year or missing entry in the SES dataset for the main contributing industry	
isSesIntpl	In years between surveys, SES is interpolated	In years between surveys, SES is interpolated	Can apply in a survey year if isSesConf == TRUE. In this case, the confidential value is suppressed and replaced with the interpolated value if available.
isLfsNA	There is no entry in the LFS dataset of a specific category of a specific industry-country-year	There is no entry in the LFS dataset of a specific category of the main contributing industry-country-year	
isNatHwNA	HW NACE2 n.a.	-	Blank entry in the dataset of a specific industry-country-

[12] Member States produce two reliability limits (A and B) based on their sample size and on their sample design, using the number of surveyed workers as a measure. If the number of workers in a certain sub-group is below limit A, no data can be published. If it is between limits A and B, then it can be published but flagged as non-reliable.

Flag	Condition data sheets		Comments
	NACE2	NACE1	
			year
isNatD1NA	D1 NACE2 n.a.	-	Blank entry in the dataset of a specific industry-country-year
sHWBridgeNA	HW bridge n.a.	-	Missing bridge of a specific country-year
isD1BridgeNA	D1 bridge n.a.	-	Missing bridge of a specific country-year

B. External flags on data

Flag	Condition data sheets	Comments
	Any of the following internal data flags activated	
isHoursVeryUnr	isLfsVeryUnr == TRUE	
isHoursUnr	isLfsUnr == TRUE	isHoursUnr == T whenever isHoursVeryUnr == T
isHoursConf	isLfsConf == TRUE	blank
isHoursNA	isLfsNA == T |isNatHwNA == T | isHWBridgeNA == T	blank
isEarnUnr	isSilcUnr == T	blank
isEarnConf	isSilcConf == T | isSesConf == T	blank
isEarnNA	isSilcNA == T | (isSesNA == T & isSesIntpl == NA) | isNatD1NA == T | isD1BridgeNA == T	Earnings might be missing for a number of reasons: 1) No entry in SILC (only applies to agricultural sectors); 2) No SES entry in a survey year; 3) SES cannot be interpolated in a non-survey year; 4) Any of the relevant bridge matrices is missing for older waves.

C. External flags on QALI

Flag	Condition data sheets	Comments
	Any of the following external data flags activated	
isQaliVeryUnr	isHoursVeryUnr == T	blank
isQaliUnr	isHoursUnr == T | isEarnUnr == T	
isQaliConf	* | isEarnConf == T	blank
IsQaliNA	isHoursNA == T | isEarnNA == T	blank

*	**NACE2**	LFS frequency of the whole industry-country-year ≤ 3
	NACE1	LFS frequency of the whole main contributing industry-country-year ≤ 3, currently relies on weighted average of frequencies.

References

Acheson, J. and Franklin, M. (2011) Quality-adjusted labour input: new quarterly estimates for 1993 to 2009 and annual estimates from 1970, *Economic and Labour Market Review* 5(4):22-46.

Buiten,G. Kampen J. and Vergouw S. (2009) Producing historical time series for STS-statistics in NACE Rev.2: Theory with an application in industrial turnover in the Netherlands (1995-2008). *Statistics Netherlands Discussion paper* (09001).

Diewert, Erwin W. (1976) Exact and Superlative Index Numbers, *Journal of Econometrics 4(2):*115-45.

Eurostat (2013) European System of Accounts (ESA2010), Publication Office of the European Union, Luxembourg.

Goodridge, P. (2007) Index numbers, Economic and labour market review 1(3):54-57.

OECD (2001), Measuring Productivity: OECD Manual, OECD, Paris.

Statistics Sweden (2013) Revising Surveys — Linking Old and New Data. Background Facts, Population and Welfare Statistics.

United Nations, European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development and World Bank (2009), System of National Accounts 2008, United Nations: New York.

Törnqvist, L. (1936) The Bank of Finland's consumption price index, Bank of Finland Monthly Bulletin 10, 1-8.

LFS:

http://ec.europa.eu/eurostat/documents/1978984/6037342/EULFS-Database-UserGuide.pdf

http://ec.europa.eu/eurostat/documents/1978984/6037342/EU-LFS-explanatory-notes-from-2016-onwards.pdf

http://ec.europa.eu/eurostat/statistics-explained/index.php/EU_labour_force_survey

SES:

http://ec.europa.eu/eurostat/cache/metadata/en/earn_ses2010_esms.htm

http://epp.eurostat.ec.europa.eu/portal/page/portal/labour_market/documents/SES2010 %20Implementation%20arrangements-final%2024.11.2010.pdf

http://ec.europa.eu/eurostat/web/microdata/structure-of-earnings-survey

EU-SILC:

http://ec.europa.eu/eurostat/web/income-and-living-conditions/methodology/list-variables

http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions