European Commission

ISSN 2443-8022 (online)

Output Gap Estimation Using the European Union's Commonly Agreed Methodology: Vade Mecum & Manual for the EUCAM Software

François Blondeau, Christophe Planas and Alessandro Rossi

DISCUSSION PAPER 148 | OCTOBER 2021

EUROPEAN ECONOMY

Economic and Financial Affairs

European Economy Discussion Papers are written by the staff of the European Commission's Directorate-General for Economic and Financial Affairs, or by experts working in association with them, to inform discussion on economic policy and to stimulate debate.

DISCLAIMER

The views expressed in this document are solely those of the author(s) and do not necessarily represent the official views of the European Commission.

Authorised for publication by Géraldine Mahieu, Director for Investment, Growth and Structural Reforms.

LEGAL NOTICE

Neither the European Commission nor any person acting on behalf of the European Commission is responsible for the use that might be made of the information contained in this publication.

This paper exists in English only and can be downloaded from
https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en.

Luxembourg: Publications Office of the European Union, 2021

PDF ISBN 978-92-76-38749-7 ISSN 2443-8022 doi:10.2765/217592 KC-BD-21-005-EN-N

© European Union, 2021
Non-commercial reproduction is authorised provided the source is acknowledged. For any use or reproduction of material that is not under the EU copyright, permission must be sought directly from the copyright holders.

CREDIT
Cover photography: © iStock.com/shironosov

European Commission
Directorate-General for Economic and Financial Affairs

Output Gap Estimation Using the European Union's Commonly Agreed Methodology

Vade Mecum & Manual for the EUCAM Software

François Blondeau, Christophe Planas and Alessandro Rossi

Abstract

The EUCAM software is the officially validated tool for estimating potential growth and output gaps according to the **E**uropean **U**nion's **C**ommonly **A**greed **M**ethodology. This EUCAM methodology, which is comprehensively described in Havik et al. (2014), has been agreed between the EU's Member States during discussions held at regular meetings of the Output Gap Working Group. The EUCAM software integrates all the operations that lead to the output gap and potential growth estimates, including data transformations, filtering, model estimation, and forecasts. Its user-friendly environment facilitates multi-country analyses and comparisons across different data vintages. It is open source and distributed together with the data files for EU countries at the publicly accessible repository *circabc.europa.eu/ui/welcome* (with users then prompted to follow the path "Browse categories - European Commission - Economic and Financial Affairs - Output Gaps - Library - PF method - EUCAM software"). The EUCAM software enables users to quickly replicate the output gap calculations made by the European Commission.

JEL Classification: C10, E60, C87.

Keywords: Macroeconomic Policy, Econometric Methods, Computer Programs, Econometric Software.

Acknowledgements: Werner Roeger, Valerie Vandermeulen, Rafal Raciborski and colleagues in Unit B3 of Directorate-General for Economic and Financial Affairs are gratefully acknowledged for their comments and suggestions. Closing date for this version was September 2021.

Contact: François Blondeau, francois.blondeau@ec.europa.eu; Christophe Planas, christophe.planas@ec.europa.eu; Alessandro Rossi, alessandro.rossi1@ec.europa.eu.

CONTENTS

Executive summary 2

1. Introduction 4

2. Overview of the commonly agreed methodology 6
   2.1. Potential output and output gap until T+2 6
      2.1.1. Labour 7
      2.1.2. Capital 10
      2.1.3. Total Factor Productivity 10
   2.2. Medium-term forecasts: from T+3 to T+5 12
      2.2.1. Labour 12
   2.3. Country specificities 13
      2.3.1. Estonia 13
      2.3.2. Ireland 13
      2.3.3. Latvia 14
      2.3.4. Luxembourg 14

3. User manual 16
   3.1. Installation 16
   3.2. Getting started: the file EUCAMv10.xlsm 18
      3.2.1. Worksheet Source 18
      3.2.2. Worksheet HP settings & series extensions 20
      3.2.3. Worksheet TFP 22
      3.2.4. Worksheet NAWRU 28
      3.2.5. Worksheet Output Gap 33
      3.2.6. Worksheet Manual 37
      3.2.7. Worksheet Upgrades 37

4. Data description 38
   4.1. AMECO 38
   4.2. CUBS data 41
   4.3. Population 41

5. Conclusion 43

APPENDIX A AMECO data & acronyms 44
APPENDIX B Output files 49
APPENDIX C The Hodrick-Prescott filter 52
APPENDIX D The autoregressive model 52

REFERENCES 53

Executive Summary

This discussion paper provides a detailed description of a new, user-friendly, software tool aimed at simplifying the process of calculating potential output and output gap estimates, using the EU′s commonly agreed, production function methodology (henceforth referred to as the EUCAM i.e. the EU′s Commonly Agreed Methodology). It also acts as a Vade Mecum for EUCAM since in addition to providing a user manual for the software, it also includes a pedagogical summary of the key features of the methodology, as well as a comprehensive description of all the data sources and variables used in the calculations.

In terms of policy use, potential output and output gap estimates are essential for assessing the productive (supply side) capacity and the cyclical (demand side) positions of all of the EU′s economies. They are estimated by DG ECFIN, using the transparent EUCAM rules as agreed by the Economic Policy Committee′s Output Gap Working Group and the EPC and endorsed by the ECOFIN Council. The estimates are applied in the framework of various economic and fiscal surveillance processes. More specifically, the output gap indicator is used to cyclically adjust the budget balances of the Member States (i.e. to produce their structural budget balances) and the potential output indicator is used for assessing debt sustainability and for comparing EU economies′ net government expenditures compared to their potential growth rates (which is used as part of the expenditure benchmark criterion under the preventive arm of the Stability and Growth Pact). In addition, potential output can also be relevant for evaluating the sustainability and effectiveness of different structural reform agendas, aimed at boosting the productive capacity of individual EU countries.

This paper has been written to complement the 2014 paper (Havik et al., 2014) which currently provides the most comprehensive description of the EU′s official output gap methodology. To put this new EUCAM software tool and the current paper in their proper context, they are meant to be more practical and user-oriented, focusing only on the essential information needed to compute the different indicators whilst encouraging users to refer to the 2014 paper for a more exhaustive description of the method and of the underlying economic theory.

The EUCAM software is an open source program which has been developed thanks

to the collaboration of DG ECFIN and the Joint Research Centre. Its release is an important step in enhancing the user-friendliness of the EU′s output gap estimation methodology. The EUCAM software is used to calculate the official EC output gap and potential output estimates since Spring 2021. It aims at streamlining the estimation of the economic indicators used in the calculations and at making the process more transparent. Regarding the first aim, it provides a common graphical user interface which allows users to control each step of the calculation process. Regarding the transparency goal, the EUCAM software relies entirely on open source technology with publicly released code, allowing outside contributions to be considered in terms of the future development of the software.

EUCAM is available on CIRCABC together with all of the data files (provided via Excel files) and models needed to fully replicate the Commission′s latest output gap calculations for each of the EU′s Member States, as well as for the euro area and EU aggregates (using the estimates and forecasts for a wide range of economic variables contained in either the Commission′s Spring or Autumn forecasting exercises). The EUCAM software integrates the various programmes and data modules, which have steadily grown in number over the years since the inception of the method in 2002, with the result that all of the different components of the calculation process can now be executed via one single graphical user interface. This interface offers a range of user-friendly facilities including menu-driven input options; analytical tools for multi-country analyses; as well as graphical tools for comparisons across countries or vis-à-vis previous data vintages.

In terms of the structure of the paper, following a short introductory section, the paper proceeds to discuss briefly the essential elements of EUCAM by (1) describing the components of its production function approach (i.e. labour, capital and total factor productivity); (2) the way these components are forecasted for the medium-term projections (over a three to five year horizon); (3) and finally describes country specificities that are economically justified exceptions to the methodology. The third section discusses the EUCAM software, starting with the installation process, and moving to operational instructions. This section describes the step-by-step functioning of the software using both screen captures and text to guide the user through the

process. The final section includes a comprehensive overview of the various data sources used in the EUCAM calculations and of the specific data needed for the estimations.

This specific structure has been chosen since one of the main aims of this discussion paper is to demonstrate that EUCAM is not as complex as many commentators have suggested. Consequently, all the requisite elements needed to trace the final output gap results back to the initial data inputs are made available in summary form. This is achieved since, in addition to a description of the user interface and data inputs used for the calculations, the paper also includes the key equations which ultimately determine the output of the methodology and a description of the econometric methodology implemented to estimate the pivotal NAWRU and potential TFP variables. In this way, interested readers / users can discover that EUCAM is not a complex "black-box" but in fact is a relatively simple, rules-based, and 100% transparent methodology where the important data inputs, allied with the key mathematical equations underpinning the methodology, are combined to produce the final potential output and output gap estimates.

Finally, EUCAM should not be seen in static terms since there is a strong likelihood that specific details of the approach will be amended by the EU′s Member States in the years to come on the basis of the practical experience garnered from using the methodology in the Commission′s various surveillance exercises. As the methodology changes, updated versions of the software and of the current paper will be placed on CIRCABC. The broad structure of the current paper, however, will be retained since it tries to combine the benefits of having a Vade Mecum of the methodology itself, allied to the practicality of a "hands-on" user manual for the software which is used to replicate, in a logical step-by-step process, the potential output and output gap calculations used for EU policy surveillance purposes.

1 Introduction

The EUCAM software enables the European Union′s Commonly Agreed Methodology to estimate potential growth and output gaps. This methodology, which is described in Havik et al. (2014), has been agreed between EU Member States during discussions held at regular

meetings of the Output Gap Working Group (OGWG)[1]. It relies on the Cobb-Douglas production function; a brief overview is given in Section 2. A user manual to the EUCAM software is provided in Section 3. The software performs all the operations that lead to the output gap and potential growth estimates:

- it prepares all the preliminary data transformations and forecast extensions;
- it applies the Hodrick-Prescott (HP) filter to detrend the participation rate and hours worked;
- it runs Program GAP (Planas and Rossi, 2020) to get potential Total Factor Productivity (TFP) and the Non-Accelerating Wage inflation Rate of Unemployment (NAWRU);
- it puts all the intermediate results together to build the potential growth and output gap estimates;
- and, given medium-term extensions of the working age population and the investment to capital ratio, it elaborates five-year-ahead forecasts of potential growth.

Several facilities like menu-driven inputs, multi-country analysis, and graphical comparisons using another data vintage are offered. The program is open-source and can be downloaded in CIRCABC at

circabc.europa.eu/ui/welcome

following the path Browse categories - European Commission - Economic and Financial Affairs - Output Gaps - Library - PF method - EUCAM software. Users are kindly invited to read the EU Licence Agreement. The program runs on 64-bit computers equipped with MS Windows 10. Installation is described in Section 3. For application to EU Member States, the official data set currently used by the European Commission is also provided via Excel files. All details about this data set are given in Section 4. Section 5 concludes.

[1]The OGWG members are gratefully acknowledged for their suggestions and software testing.

2 Overview of the commonly agreed methodology

For the sake of completeness we give a brief overview of the EUCAM; interested readers can find a more exhaustive description in Havik et al. (2014). Given yearly observations until time T plus additional two-year-ahead forecasts for all input variables that come from the European Commission′s Spring and Autumn Economic Forecasts, potential growth and output gap are first estimated until time T+2 as explained in Section 2.1. These results are then used to build medium-term forecasts from T+3 to T+5 using a simultaneous system of equations which is discussed in Section 2.2.

2.1 Potential output and output gap until T+2

The EUCAM assumes that output Y is produced by labour L, capital K, and total factor productivity TFP in a Cobb-Douglas technology as in:

$$Y = TFP\ L^{\alpha}\ K^{1-\alpha} \qquad \text{with } \alpha = 0.65 \tag{2.1}$$

Potential output $YPOT$ is determined by potential total factor productivity $POTTFP$, potential labour LP, and capital according to:

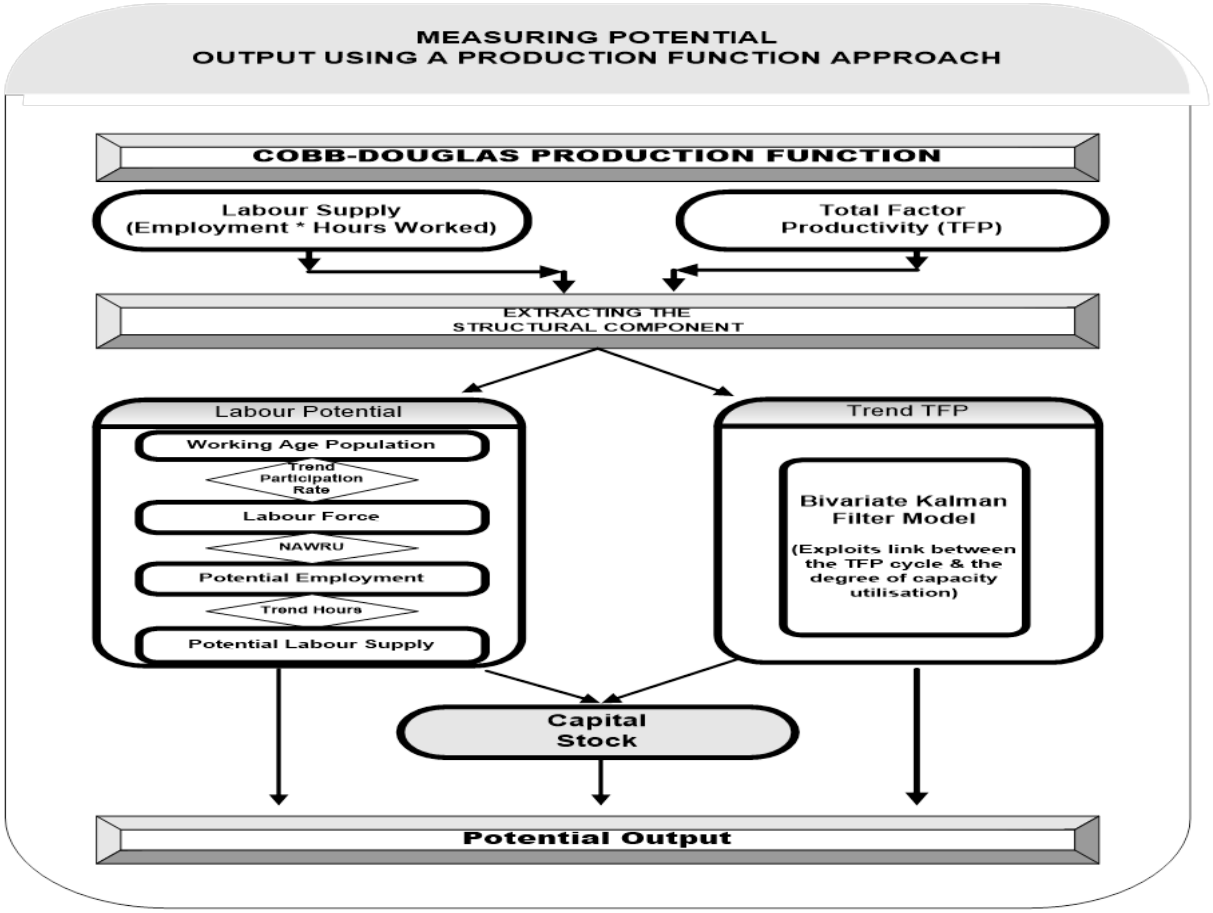
$$YPOT = POTTFP\ LP^{\alpha}\ K^{1-\alpha} \tag{2.2}$$

The output gap $YGAP$ relates potential to GDP as in:

$$Y = YPOT(1 + YGAP/100) \tag{2.3}$$

where $YGAP$ is given in percentage points. Figure 1 gives an overview of the T+2 methodology, which is reproduced from Havik et al. (2014).

FIGURE 1 Overview of the production function approach



Labour, capital, and TFP are described next.

2.1.1 Labour

Labour is measured in terms of hours as the product of hours worked per employee $hpere_t$ times the number of employees $empl_t$:

$$L_t = hpere_t \times empl_t \tag{2.4}$$

Potential labour LP_t equals the product of the hours worked trend $hperehp_t$ times the employment trend $emplp_t$:

$$LP_t = hperehp_t \times emplp_t \tag{2.5}$$

The trend in hours worked is calculated using the HP filter with an inverse signal to noise ratio λ set equal to 10, after extending the series from T+3 to T+8 using an autoregressive model (see Appendix C & D):

$$heperehp_t = HP(hpere_t, t = 1, \cdots, T+8, \lambda = 10) \tag{2.6}$$

To obtain the employment trend, the total number of employees is first decomposed into the working age population $popw_t$, the participation rate $part_t$, and the rate of employment, or equivalently one minus the harmonized rate of unemployment $1 - lurharm_t/100$:

$$empl_t = popw_t \times (part_t/100) \times (1 - lurharm_t/100) \tag{2.7}$$

where both the participation rate and the labour unemployment rate are in %. The potential number of employees verifies:

$$emplp_t = popw_t \times (parts_t/100) \times (1 - nawru_t/100) \tag{2.8}$$

where $parts_t$ denotes the trend in participation rate and $nawru_t$ the non-accelerating wage inflation rate of unemployment. The trend in participation rate is calculated using the HP filter with an inverse signal to noise ratio λ set equal to 10, after extending the series from T+3 to T+8 using an autoregressive model:

$$parts_t = HP(part_t, t = 1, \cdots, T+8, \lambda = 10) \tag{2.9}$$

where the participation rate is obtained by inverting (2.7).

The trend unemployment rate is calculated as an anchored NAWRU (Hristov et al., 2017). In a first step the unemployment rate is decomposed in a trend (i.e. NAWRU) and a cycle which are assumed to evolve stochastically as in:

$$\begin{aligned} lurharm_t &= nawru_t + c_t \\ \Delta nawru_t &= \eta_{t-1} + a_{nt} \\ \eta_t &= \eta_{t-1} + a_{\eta t} \\ c_t &= \phi_{c1} c_{t-1} + \phi_{c2} c_{t-2} + a_{ct} \end{aligned} \tag{2.10}$$

where Δ denotes first-difference. The trend component ($nawru_t$) follows a second-order integrated process without level shocks in all EU Member States, i.e. $V(a_{nt}) = 0$, except for Slovenia for which a random walk without drift is assumed, i.e. $V(a_{\eta t}) = 0$. The cyclical component of unemployment is related to a labour cost indicator w_t through the Phillips curve equation:

$$w_t = \mu_w + \phi_{w1} w_{t-1} + \beta_0 c_t + \beta_1 c_{t-1} + \gamma_w' \Delta^2 z_t + a_{wt} \tag{2.11}$$

All shocks $a_{nt}, a_{\eta t}, a_{ct}$, and a_{wt} are independent and normally distributed white noises. The vector $\Delta^2 z_t$ contain the second difference of exogenous variables such as labour productivity, terms-of-trade, and the wage share, whose measurement is explained in Section 4.

The Phillips curve (2.11) is compatible with both backward- and forward-looking expectations: with backward-looking expectations the labour cost indicator corresponds to the change in wage inflation whereas with forward-looking expectations the relevant indicator is the growth of real unit labour cost - see Section 4. No exogenous information is used in the forward-looking Phillips curve. Instead, the forward-looking assumption leads to the restriction $\beta_1 = \beta_0(\phi_{w1} - 0.99)/(0.99\phi_{w1} - 1)\phi_{c2}$, where 0.99 is the assumed discount factor.

Model (2.10)-(2.11) is estimated by maximum likelihood after casting the model equations in a state space format and launching the Kalman recursions from a diffuse initialisation; details can be found in the GAP Manual.

In a second step the NAWRU is corrected to incorporate an anchor S_t to which it is assumed to converge at some horizon $T + h$ under the hypothesis of no-policy change; in short it is assumed that $nawru_{T+h} = S_{T+h}$, where h is typically equal to ten years. The anchor is built using a panel regression on structural indicators of the labour market (Hristov and Roeger, 2020).

Plugging the NAWRU estimates together with the working age population and the smoothed participation rate into (2.5) yields potential labour up to T+2.

2.1.2 Capital

The net capital stock is calculated using the Perpetual Inventory Method. Capital stock grows through real gross fixed capital formation IQ and it decreases with the consumption of capital CFC. Given the investment deflator $defl$ and a starting point in 1960, real capital stock K is measured as:

$$K_t = K_{t-1} + IQ_t - \frac{CFC_t}{defl_t} \tag{2.12}$$

Two-year-ahead forecasts are provided by the country-desks in DG ECFIN. Capital contributes entirely to potential output and it is not subject to any transformation in the EUCAM.

2.1.3 Total Factor Productivity

TFP is calculated by exponentiating the Solow residual sr_t defined by:

$$sr_t = \log Y_t - \alpha \log L_t - (1-\alpha) \log K_t \tag{2.13}$$

Two-year-ahead forecasts of the Solow residual are provided by the country-desks in DG ECFIN as part of the European Economic Forecasts. The Solow residual including the two-year-ahead extension is then decomposed into a trend srk_t plus a cycle c_t using the model:

$$\begin{aligned} sr_t &= srk_t + c_t \\ \Delta srk_t &= \mu_p + \eta_{t-1} + a_{pt} \\ \eta_t &= \rho \eta_{t-1} + a_{\eta t} \\ c_t &= 2\ Acos(2\pi/\tau) c_{t-1} - A^2 c_{t-2} + a_{ct} \end{aligned} \tag{2.14}$$

The trend component srk_t follows a damped trend model with average growth μ_p. The cyclical component c_t follows instead a second-order autoregressive process which is parameterized in terms of amplitude A and periodicity τ. The productivity cycle also appears in the

fluctuations of capacity utilization, $cubs_t$, so the model is completed with the measurement equation:

$$\begin{aligned} cubs_t &= \mu_{cu} + \beta_{cu} c_t + e_t \\ e_t &= \phi_{cu} e_{t-1} + a_{cut} \end{aligned} \tag{2.15}$$

where e_t is an unobserved idiosyncratic component which can be autocorrelated. All shocks, namely $a_{pt}, a_{\eta t}, a_{ct}$, and a_{et} are independent and normally distributed white noises. The cubs indicator is built from capacity utilization surveys in industry and two economic sentiment indicators for construction and services - see Section 4. Contrary to the Solow residual, no T+2 forecasts are available for cubs which ends in time T or sometimes earlier. To cope with this the estimation procedure allows for missing observations.

Model (2.14)-(2.15) is estimated in the Bayesian framework given prior distributions for each EU Member State. Given the prior distributions, the Solow residual, and the capacity utilization series, the trend component srk_t is estimated by its posterior mean in a Bayesian inference as explained in the GAP Manual. The estimate of potential TFP is then obtained as:

$$POTTFP_t = \exp(srk_t) \tag{2.16}$$

Plugging potential TFP (2.16), potential labour (2.5), and capital into (2.2) yields potential GDP up to T+2 together with the output gap.

2.2 Medium-term forecasts: from T+3 to T+5

Potential output and capital are jointly forecast from T+3 to T+5 using the following system of non-linear equations:

$$\begin{aligned} YPOT_t &= \exp(srk_t)\ LP_t^{\alpha}\ K_t^{1-\alpha} \\ K_t &= IQ_t + (1-\delta_t)\ K_{t-1} \\ IQ_t &= (IYPOT_t/100)\ YPOT_t \\ Y_t &= YPOT_t\ (1 + YGAP_t/100) \end{aligned} \tag{2.17}$$

Given inputs from srk_t, LP_t, δ_t, $IYPOT_t$, $YGAP_t$, the model above yields medium-term projections for $YPOT_t$, IQ_t, K_t, Y_t, and sr_t, using the recursive method discussed in Juillard (1996). The output gap which is available until T+2 is extended to T+5 by assuming that it closes in three years as in:

$$\begin{aligned} YGAP_{T+3} &= \frac{2}{3}\ YGAP_{T+2} \\ YGAP_{T+4} &= \frac{1}{3}\ YGAP_{T+2} \\ YGAP_{T+5} &= 0 \end{aligned} \tag{2.18}$$

Investment to potential ratio $IYPOT_t$ is extended to T+5 using an autoregressive model. The other inputs are described below.

2.2.1 Labour

Potential labour in (2.5)-(2.8) depends on the working age population, on the trend participation rate, and on the NAWRU. The working age population is available until T+2. Predictions until T+5 are built using the long-range projections of the 15-74 population by Eurostat (POPAF) as in:

$$popw_t = popw_{t-1} \times \frac{POPAF_{t-1} + POPAF_t}{POPAF_t + POPAF_{t+1}} \tag{2.19}$$

The NAWRU is extended from T+3 to T+5 according to:

$$\begin{aligned} nawru_{T+3} &= nawru_{T+2} + \frac{1}{2}(nawru_{T+2} - nawru_{T+1}) \\ nawru_{T+4} &= nawru_{T+3} \\ nawru_{T+5} &= nawru_{T+4} \end{aligned} \tag{2.20}$$

Both the trend of hours worked per employee in (2.6) and the trend participation rate in (2.9) are available until T+5. Plugging them together with the population forecasts (2.19) and the nawru extension (2.20) into (2.5)-(2.8) yields potential labour until T+5.

2.3 Country specificities

On 4 September 2017, the Economic and Financial Committee approved principles and governance rules for making economically justified country-specific exceptions to the EUCAM. The amendments adopted to date are described below.

2.3.1 Estonia

Although for Estonia the CUBS series is available since 1995, it has been decided to take 2002 as starting year like for the other Baltic countries. The change was endorsed at the December 2020 meeting of the OGWG and is in force since the Spring 2021 forecast.

2.3.2 Ireland

The capital stock series for Ireland is adjusted in order to correct an anomaly in the national accounts in this country. The anomaly is caused by a relatively small number of firms that relocated intellectual property assets to this country: it happens that the relocations increase capital stock but leave gross fixed capital formation unaffected, thus breaking the Perpetual Inventory formula (2.12). To remedy the issue, the EPC agreed on a first set of adjustments on 20 October 2016. The OGWG suggested further refinements which were adopted by the

EPC on 15 October 2018. Capital stock for Ireland K_t^{IE} is now calculated as follows:

$$\begin{aligned} \text{until 2014: } K_t^{IE} &= K_t \\ \text{2015: } K_t^{IE} &= 1.53 \times K_t \\ \text{2016: } K_t^{IE} &= K_{t-1}^{IE} + IQ_t - \frac{CFC_t}{defl_t} \\ \text{2017: } K_t^{IE} &= K_{t-1}^{IE}(1-\delta) \end{aligned} \tag{2.21}$$

where K_t is the capital stock obtained from the Perpetual Inventory Method as described in Section 2.1.2, and δ is the implied capital depreciation rate between 2015 and 2016.

2.3.3 Latvia

A measurement issue with the consumption of fixed capital distorts the calculation of the depreciation rate for Latvia. The OGWG proposed to adjust the depreciation rate for Latvia to more closely resemble that of Estonia and Lithuania. The Economic Policy Committee (EPC) endorsed this exception on 23 January 2018. The depreciation rate for Latvia is calculated as the arithmetic mean of depreciation rate of Estonia and Lithuania.

2.3.4 Luxembourg

In Luxembourg, cross-border employment amounts to 40% of total employment, pulling the participation rate (i.e. the ratio of employment to working age population) above 100%. To address this issue, the OGWG agreed to model domestic and cross-border workers separately in the calculation of the participation rate for Luxembourg. The EPC endorsed this exception by January 2018. The measurement of labour in Luxembourg is amended as follows:

$$L_t = empl_t^n \times hpere_t^n + empl_t^{cb} \times hpere_t^{cb}$$

where the superscripts 'n' and 'cb' refer to national and cross-border respectively. Expanding employment in the two groups yields:

$$\begin{aligned} L_t &= popw_t^n \times (part_t^n/100) \times (1 - lurharm_t^n/100) \times hpere_t^n + \\ &+ popw_t^{cb} \times (part_t^{cb}/100) \times (1 - lurharm_t^{cb}/100) \times hpere_t^{cb} \end{aligned}$$

Contrary to the national group, for the cross-border workers no information is available on the participation rate, the unemployment rate, and on the pool of working age population. Assuming a participation rate equal to 100% and no unemployment, the cross-border working age population amounts to cross-border employment. Assuming further that the cross-borders work on average the same number of hours as the nationals, total hours worked verifies:

$$L_t = popw_t^n \times (part_t^n/100) \times (1 - lurharm_t^n/100) \times hpere_t + empl_t^{cb} \times hpere_t \tag{2.22}$$

Equation (2.22) measures labour for Luxembourg. Potential labour is derived similarly, except that the trend of cross-border employment is needed. Rather than calculating trend cross-border employment directly, the trend of the ratio of cross-border employment to total employment is calculated via HP-filtering with inverse signal to noise ratio set equal to 10, after extending the series with forecasts from an ARI(1,1) model. Eventually, potential labour in Luxembourg is obtained by solving:

$$\begin{aligned} LP_t &= popw_t^n \times (parts_t^n/100) \times (1 - nawru_t^n/100) \times hperehp_t \\ &+ (\frac{empl_t^{cb}}{empl_t})_{hp} \times LP_t \end{aligned}$$

where the number of cross-border workers $empl_t^{cb}$ is measured as the difference between domestic and national employment:

$$\begin{aligned} empl_t^{cb} &= empl_t - empl_t^n \\ &= NETD - NETN \qquad \text{using AMECO labels.} \end{aligned} \tag{2.23}$$

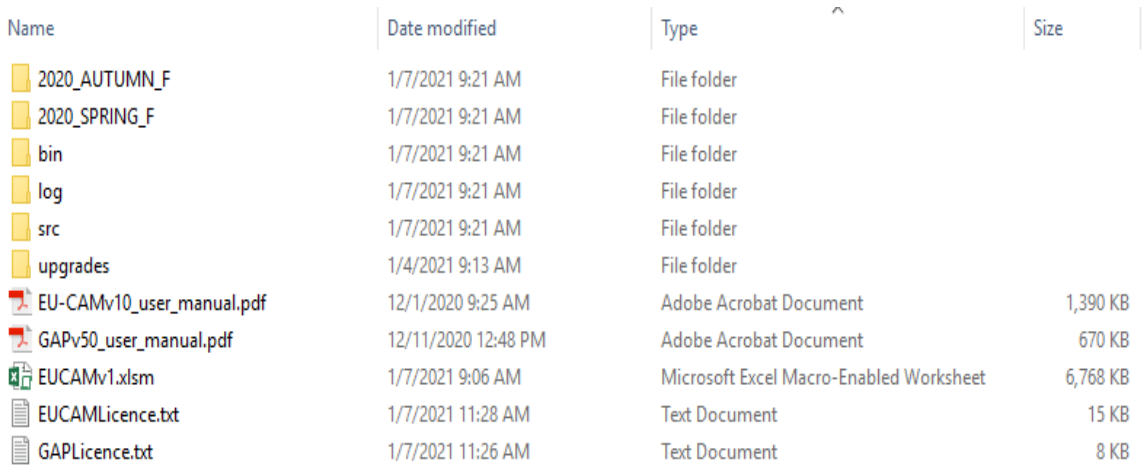
The correction implicitly yields a participation rate equal to 60% in 2017 instead of more than 100% when no distinction is made between national and cross-borders workers.

3 User manual

3.1 Installation

Installation is made by running the self-extracting executable file `EUCAMv10setup.exe`. By default the program is installed in the folder `C:\EUCAMv10` but the users can change the location. Unless a recent version of Matlab such as 2018b is already available on the disk, users are proposed to install Matlab Runtime routines. These routines serve to visualise and to tune the prior distributions for the parameters of the TFP-CU model (2.14)-(2.15). This step can be skipped by simply answering 'No' if the user is not interested in these aspects. Once completed, the installation yields the files and sub-folders shown in Figure 2:

FIGURE 2 EUCAM Main Folder



The folder structure in Figure 2 is explained below:

– Year_Season_F: contains the data files, the models, and the results for final version F of data vintage Year in period Season. Season is typically Spring or Autumn, and sometimes Winter. For instance 2020_Spring_F refers to the final version of data vintage Spring 2020.

- bin: contains the Python executable `EUCAMv10.exe`, the files related to the graphical interface, and the dynamic link library version of Program GAP, gap50dll.dll.
- log: contains log files written during program execution.
- src: contains the Python source code.
- upgrades: EUCAM can be easily updated by importing the latest program files *.bas, *.dll, and *.exe that are stored in this folder - see subsection 3.2.7 'Upgrades'.

The main folder contains the following files:

- The excel interface `EUCAMv10.xlsm`.
- The licence agreements `EUCAMLicence.txt` and `GAPLicence.txt` that the users are kindly invited to read.
- The EUCAM user-guide and the GAP manual where details about the econometric methodology implemented to estimate the NAWRU and potential TFP can be found.

The software requires that the decimal character is set to a dot as in 1.234 and not as a comma - please check your regional settings following the path Region - Additional Settings in the Windows Control Panel.

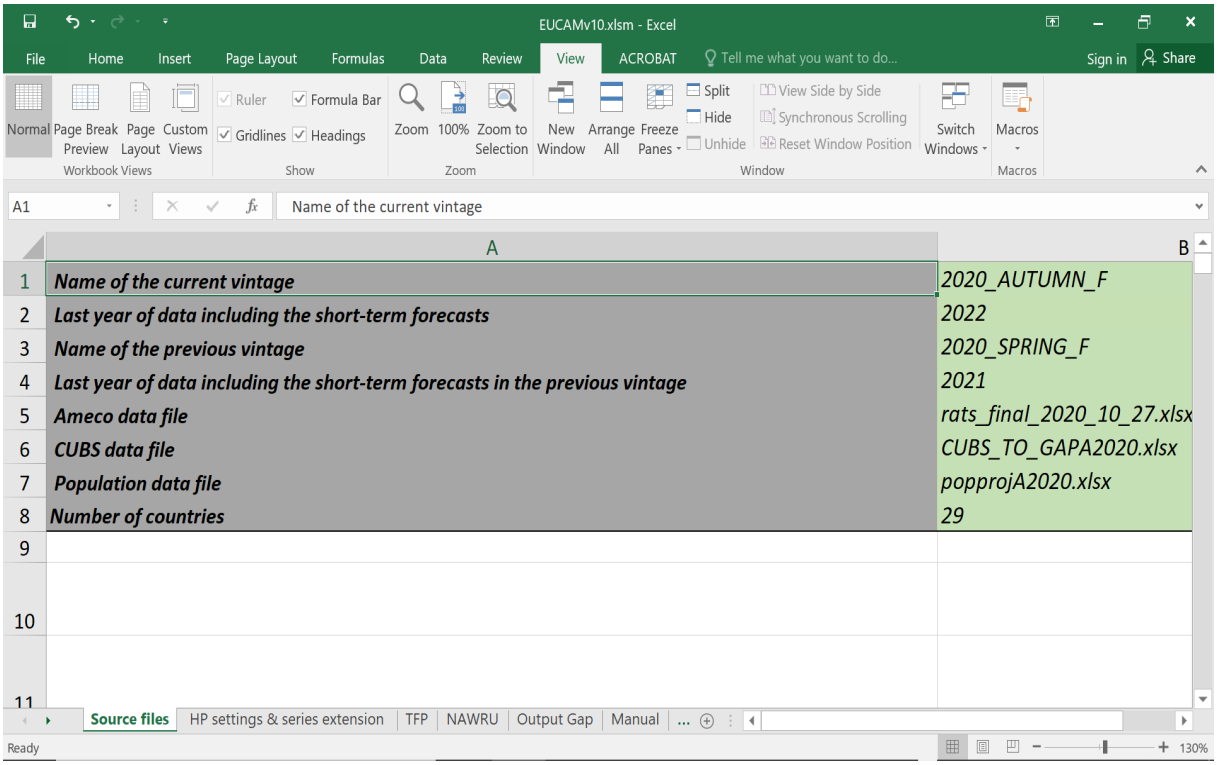
The Excel interface reads and writes namelist files (`*.nml`) which are given as input to GAP. Each namelist file contains model equations and all necessary statistical information in a human-readable format. To ease reading, it is recommended to associate the `*.nml` filetype to a preferred text editor. In Windows 10, this can be managed in the Settings area, following the path Default Apps - Choose default apps by file type.

3.2 Getting started: the file EUCAMv10.xlsm

To start the user needs to open the Excel interface `EUCAMv10.xlsm`. Seven worksheets are available. They are described below.

3.2.1 Worksheet Source

FIGURE 3 EUCAM Worksheet Source



In the worksheet Source, the user can set the :

- `Name of the current vintage`: the format is Year_Season_F, referring to the Final storage of data in Season typically Spring, Autumn, or Winter of vintage Year. All inputs and outputs related to this vintage are located in the directory named according to this name.

- `Last year of data including the short-term forecasts`: for instance, 2022 for

vintage Autumn 2020 since it is extended with two years of forecasts.

- `Name of the previous vintage`: the previous vintage to be used for comparisons, written in the same format as for current vintage. All input and output files related to this vintage are located in the directory named accordingly.

- `Last year of data including the short-term forecasts in the previous vintage`: for instance, 2021 for vintage Spring 2020 which is extended with two years of forecasts starting from 2019.

- `Ameco data file` The series in the Ameco data file are described in Section 4. A link to the equations in Section 2 is provided.

- `CUBS data` The capacity utilization series in the CUBS data file are described in Section 4.

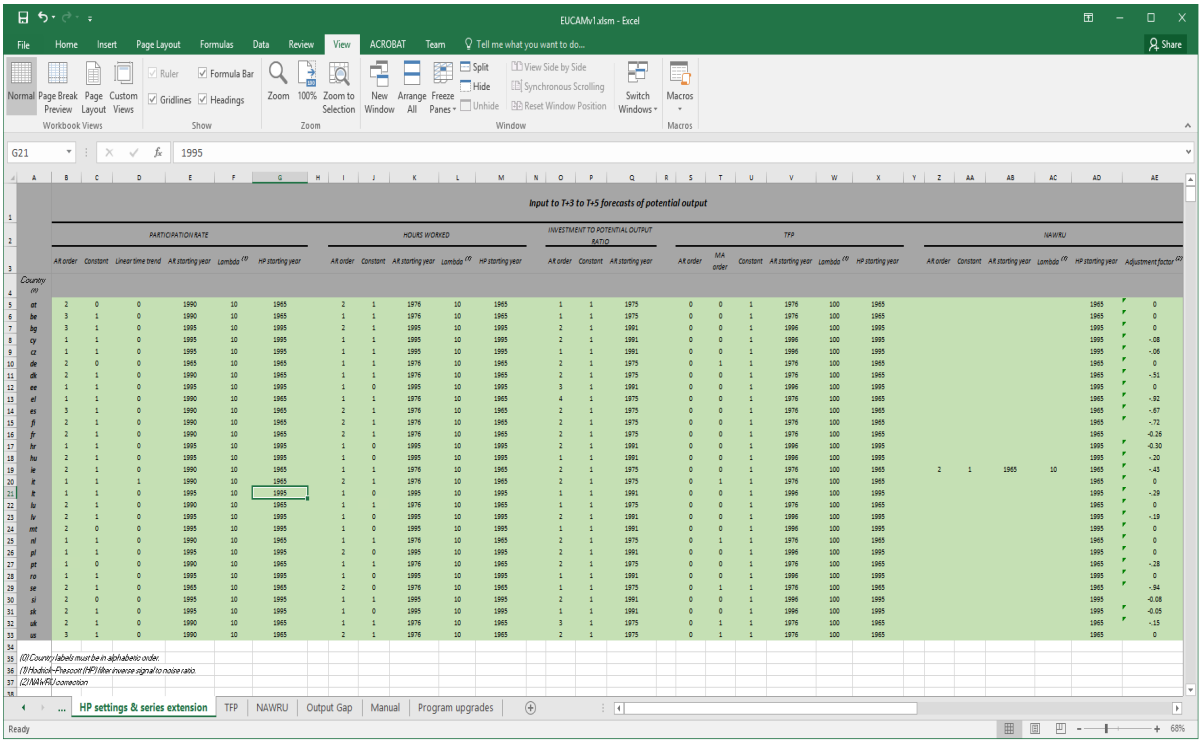
- `Population data` The series in the Population data file are described in Section 4.

The data files in the last three items must be located in the folder corresponding to the current vintage.

3.2.2 Worksheet HP settings & series extensions

The HP-filter is used to estimate the trend of the participation rate and of hours worked until T+5. The investment to potential output ratio is instead extended to T+5 using autoregressive forecasts. The worksheet is illustrated in Figure 4.

FIGURE 4 EUCAM Worksheet HP settings & series extensions



The worksheet is organized as follows:

- `Participation rate`: the user can set the autoregressive order `AR Order`, include a `Constant` or a `linear time trend` in the model used for forecast three additional years, and select the `AR Starting year` of the sample used to estimate the parameters. The inverse signal to noise ratio `Lambda` for the HP filter can be inserted in Column F, and select the `HP Starting year` for computing the filtered estimates.
- `Hours worked`: the user can set the autoregressive order `AR Order`, include or not a

`Constant`, select the `AR starting year` of the sample used to estimate the parameters, insert the inverse to noise ratio `Lambda`, and select the `HP Starting year` for computing the filtered estimates.

– `Investment to potential output ratio`: the user can set the autoregressive order `AR order`, include a `Constant`, and select the `AR starting year` for model estimation.

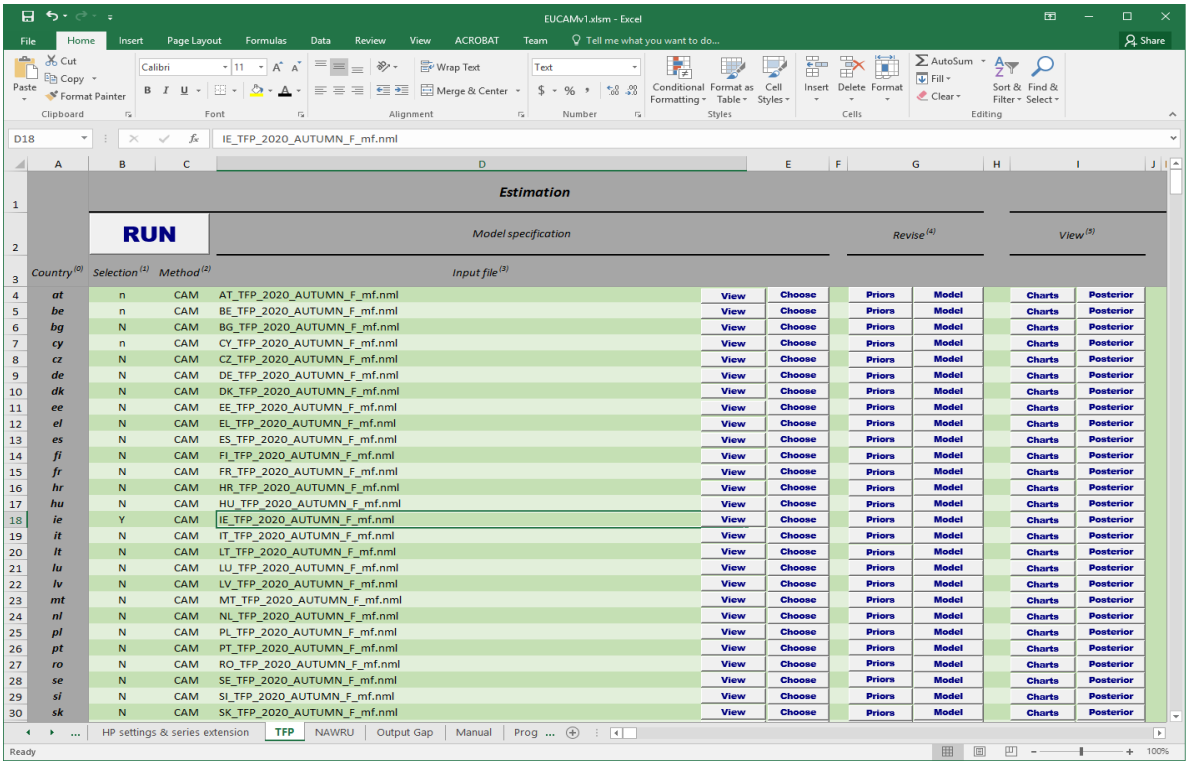
– `TFP`: the user can enter in columns S-X the settings for HP filtering as an alternative to the EUCAM for decomposing TFP.

– `NAWRU`: the user can enter in columns Z-AD the settings for HP filtering as an alternative to the EUCAM for estimating the NAWRU. This is currently used in the case of IE. The constant used for uncentering the NAWRU as discussed in Section 2.4.2 of Havik et al. (2014) appears in column AE entitled 'Adjustment factor'.

3.2.3 Worksheet TFP

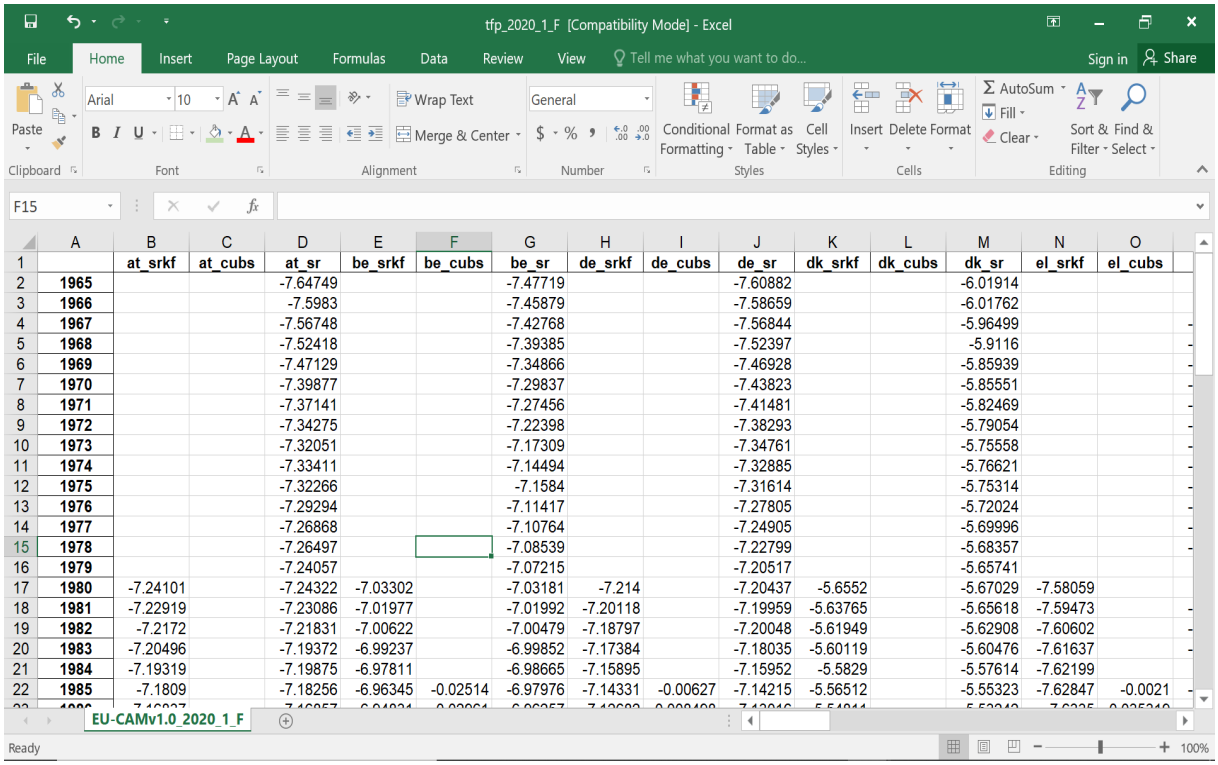
The worksheet TFP sets up the estimation of potential TFP and TFP gap up to T+2.

FIGURE 5 EUCAM Worksheet TFP



– `Selection`: the user can include or exclude a country from the TFP decomposition process by setting `Selection = Y` or `N`. If `N` is selected so that no TFP decomposition is performed, the TFP trend must be provided in an Excel file with the vintage information in its name, for instance `tfp_2019_Autumn_F.xls` in the format shown in Figure 6, otherwise no output gap calculation can be made for this country.

FIGURE 6 The data file `tfp_2019_Autumn_F.xls`



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		at_srkf	at_cubs	at_sr	be_srkf	be_cubs	be_sr	de_srkf	de_cubs	de_sr	dk_srkf	dk_cubs	dk_sr	el_srkf	el_cubs
2	1965			-7.64749			-7.47719			-7.60882			-6.01914		
3	1966			-7.5983			-7.45879			-7.58659			-6.01762		
4	1967			-7.56748			-7.42768			-7.56844			-5.96499		
5	1968			-7.52418			-7.39385			-7.52397			-5.9116		
6	1969			-7.47129			-7.34866			-7.46928			-5.85939		
7	1970			-7.39877			-7.29837			-7.43823			-5.85551		
8	1971			-7.37141			-7.27456			-7.41481			-5.82469		
9	1972			-7.34275			-7.22398			-7.38293			-5.79054		
10	1973			-7.32051			-7.17309			-7.34761			-5.75558		
11	1974			-7.33411			-7.14494			-7.32885			-5.76621		
12	1975			-7.32266			-7.1584			-7.31614			-5.75314		
13	1976			-7.29294			-7.11417			-7.27805			-5.72024		
14	1977			-7.26868			-7.10764			-7.24905			-5.69996		
15	1978			-7.26497			-7.08539			-7.22799			-5.68357		
16	1979			-7.24057			-7.07215			-7.20517			-5.65741		
17	1980	-7.24101		-7.24322	-7.03302		-7.03181	-7.214		-7.20437	-5.6552		-5.67029	-7.58059	
18	1981	-7.22919		-7.23086	-7.01977		-7.01992	-7.20118		-7.19959	-5.63765		-5.65618	-7.59473	
19	1982	-7.2172		-7.21831	-7.00622		-7.00479	-7.18797		-7.20048	-5.61949		-5.62908	-7.60602	
20	1983	-7.20496		-7.19372	-6.99237		-6.99852	-7.17384		-7.18035	-5.60119		-5.60476	-7.61637	
21	1984	-7.19319		-7.19875	-6.97811		-6.98665	-7.15895		-7.15952	-5.5829		-5.57614	-7.62199	
22	1985	-7.1809		-7.18256	-6.96345	-0.02514	-6.97976	-7.14331	-0.00627	-7.14215	-5.56512		-5.55323	-7.62847	-0.0021

– `Method`: either `CAM` or `HP`.

– Press `View` to visualise the model file which contains all information about the model specification. For instance `AT_TFP_2020_Autumn_F_m0.nml` contains a model specification for Austria. The namelist syntax is described in the GAP manual.

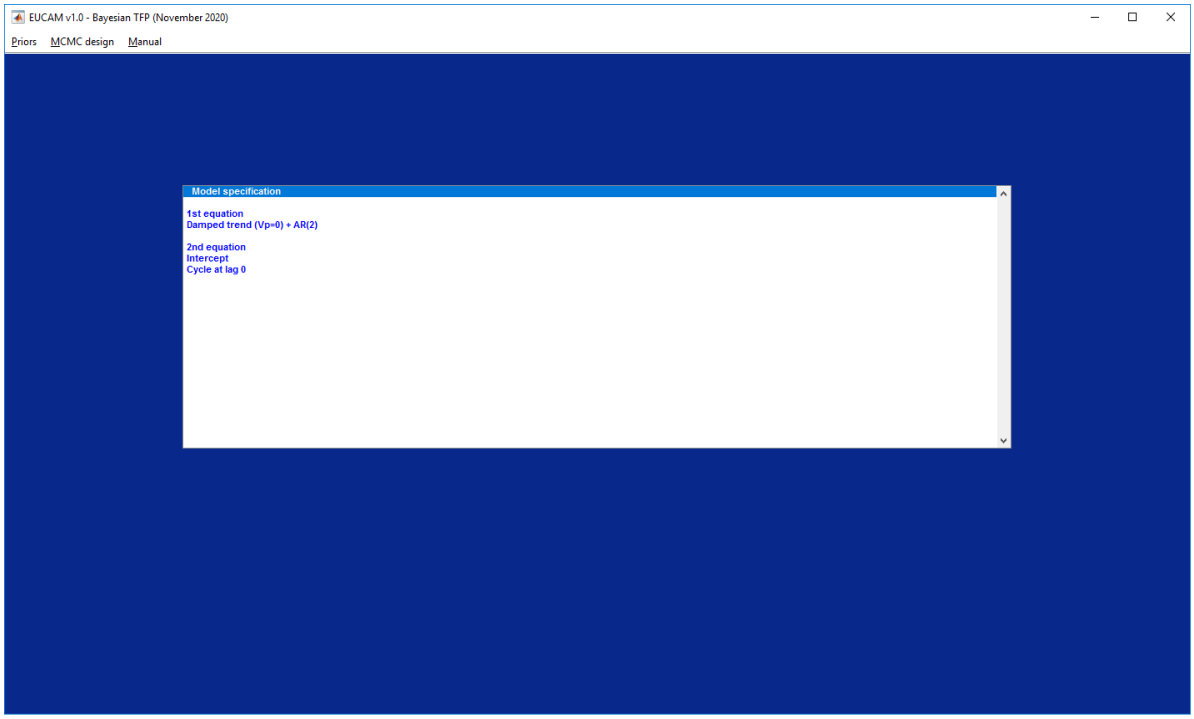
– Press `Choose` to pick a model file located in the vintage folder: The selected file appears in column D.

– Press `Priors`[2] to revise the prior distributions. The current model is left unchanged. The user is first asked to choose the name of the file which will contain the new

[2]This facility is available if the user allowed the Matlab Runtime routines to be installed running the program setup.

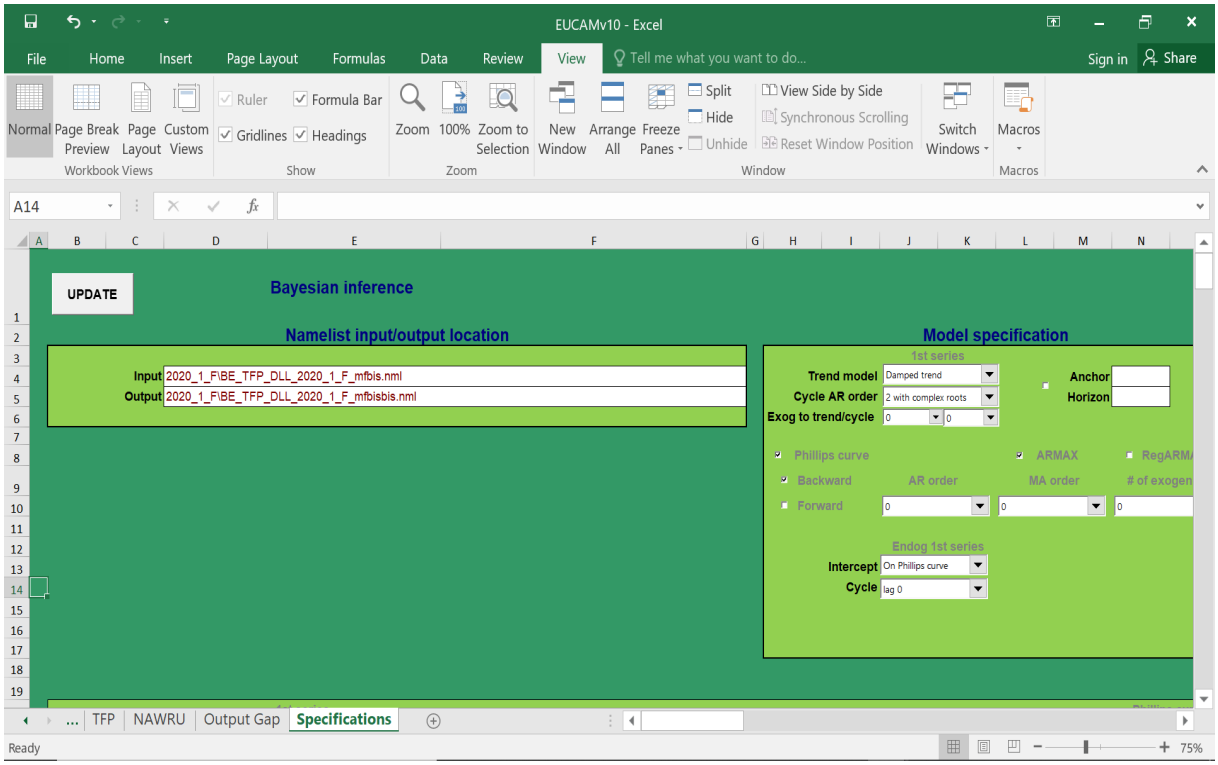
priors. Once entered, an interface where the prior distributions can be tuned through the menu-entry Priors appears as shown in Figure 7. Please notice that the interface can take several minutes to load the first time it is launched. Further details on this interface can be found in the GAP Manual.

FIGURE 7 EUCAM Worksheet TFP - Interface for updating priors



– Press `Model` to revise the model specification. This action opens the Specifications worksheet. The user can choose a model name, change the model specifications, update the bounds, and save the new model file by pressing `Update`. The interface for setting priors displayed in Figure 7 opens automatically.

FIGURE 8 EUCAM Worskheet TFP - Interface for updating the model



– Press `RUN` to estimate potential TFP for each country for which estimation is set to 'Y'.

– Press `Charts` to see graphics. The Chart button opens the file `Country_TFP_Vintage_Modelname.pdf` located in the vintage folder. Eight panels are displayed:

  – the TFP series in the current and previous vintage plus the respective trends;

  – the growth rate of TFP and trend TFP in the current and previous vintage;

  – as above with the addition of the HP trend;

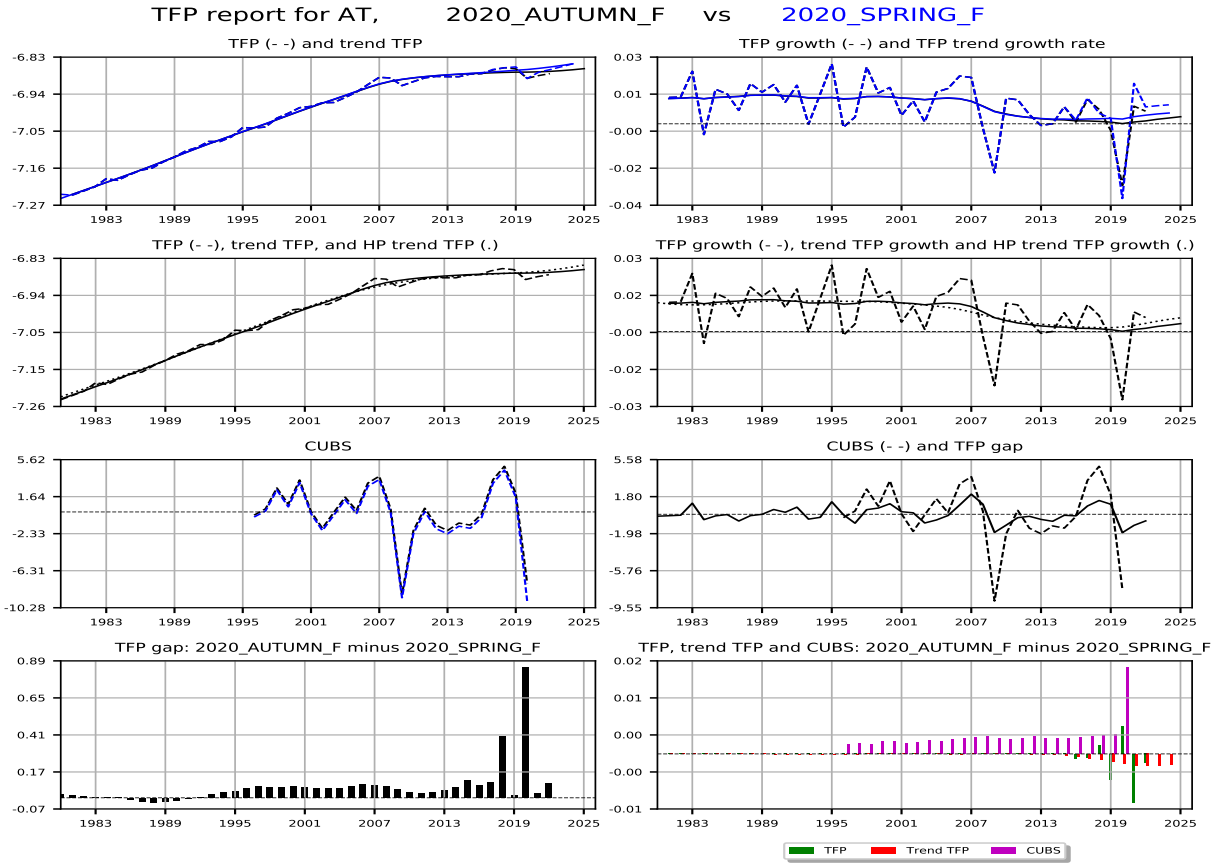
  – the CUBS series together with its cyclical part which is commonly shared with TFP;

  – the revisions to the TFP cycle compared to the previous vintage;

– the revisions to TFP, TFP trend, and CUBS compared to the previous vintage.

The charts focus on the last fourty years. An example is given in Figure 9.

FIGURE 9 EUCAM Worskheet TFP - Charts




```
Statistics for 2020_AUTUMN_F :
.      Beta coef. = 1.71
.      Cor. TFP gap/CU : 0.84

Statistics for 2020_SPRING_F :
.      Beta coef. = 1.6
.      Cor. TFP gap/CU : 0.8
```

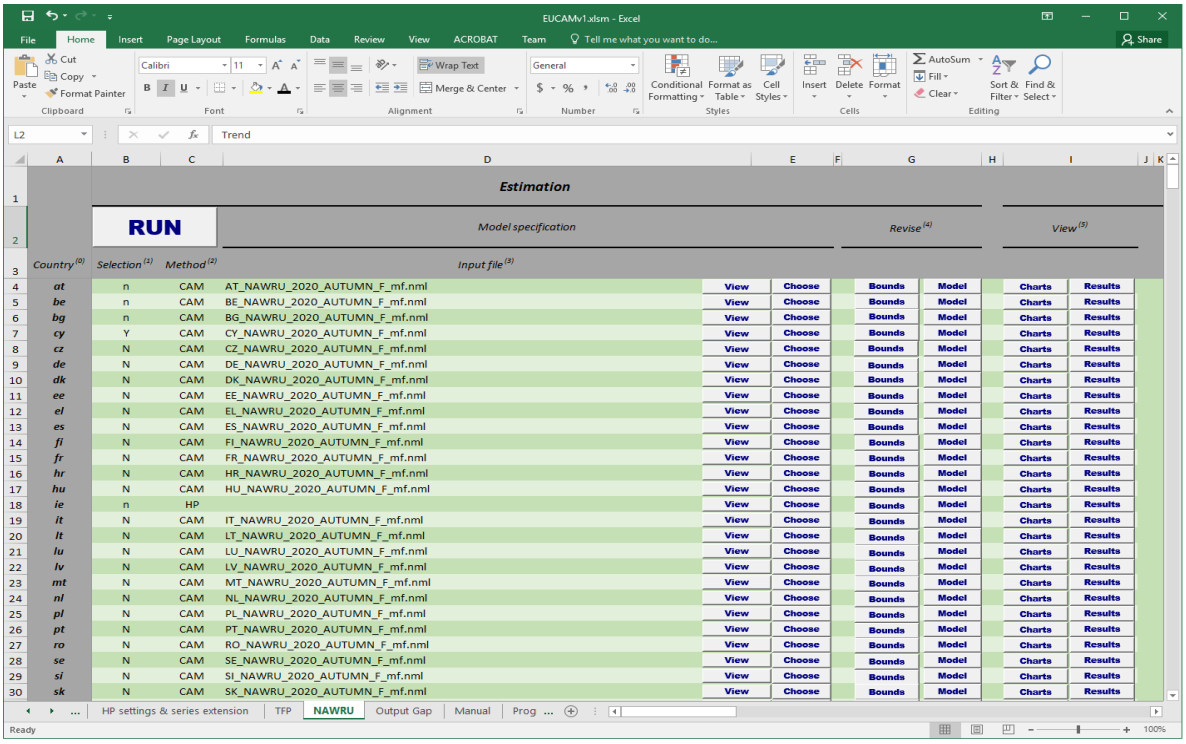
EUCAM v1 (2021-04-06 10:39:59)

– Press `Posterior` to see the posterior distribution of the estimated parameters, together with the relative prior distribution.

3.2.4 Worksheet NAWRU

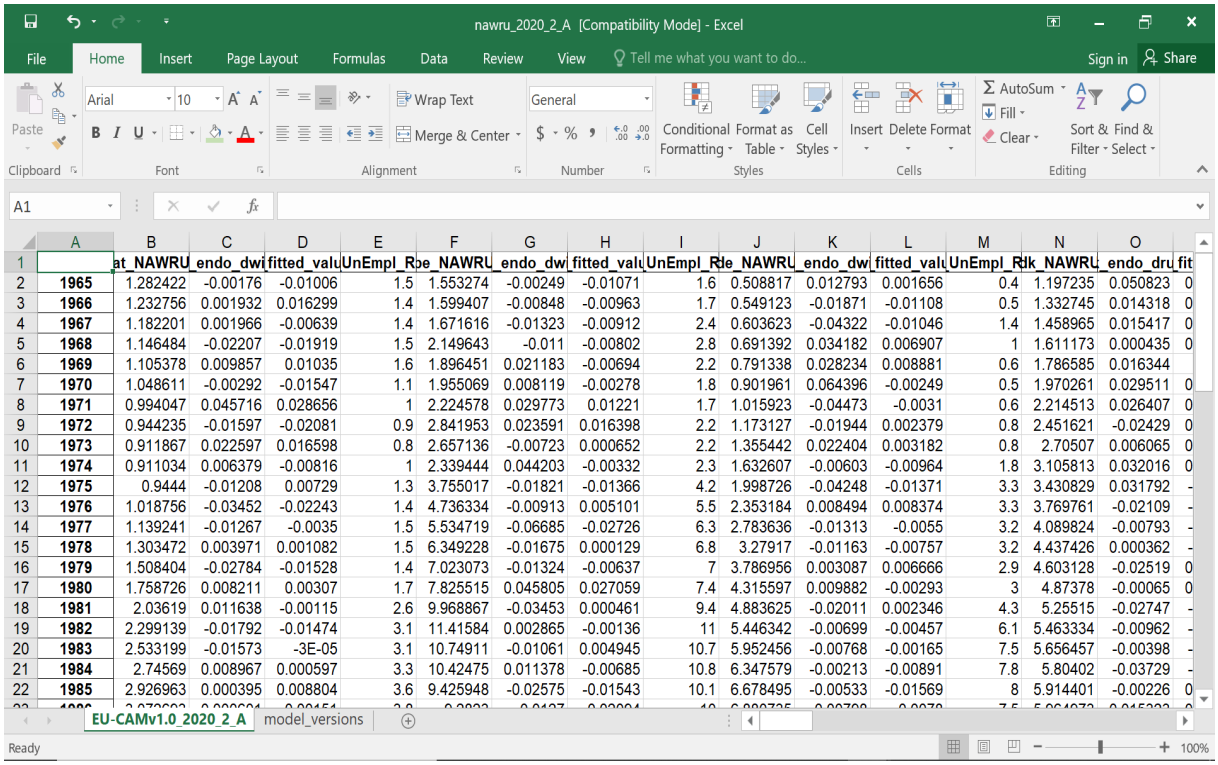
The worksheet NAWRU controls the NAWRU estimation up to T+2.

FIGURE 10 EUCAM Worksheet NAWRU



– `Selection` the user can include or exclude a country from the NAWRU estimation process by setting `Selection=Y` or `N`. If `N` is selected so that no estimation is performed, the NAWRU must be provided in an Excel file with the vintage information in its name, for instance `NAWRU_2020_Autumn_F.xls` in the format shown in Figure 11, otherwise no output gap calculation can be made for this country.

FIGURE 11 The data file NAWRU_2020_Autumn_F.xls



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		at_NAWRU	endo_dw	fitted_valu	UnEmpl_R	be_NAWRU	endo_dw	fitted_valu	UnEmpl_R	de_NAWRU	endo_dw	fitted_valu	UnEmpl_R	lk_NAWRU	endo_dru
2	1965	1.282422	-0.00176	-0.01006	1.5	1.553274	-0.00249	-0.01071	1.6	0.508817	0.012793	0.001656	0.4	1.197235	0.050823
3	1966	1.232756	0.001932	0.016299	1.4	1.599407	-0.00848	-0.00963	1.7	0.549123	-0.01871	-0.01108	0.5	1.332745	0.014318
4	1967	1.182201	0.001966	-0.00639	1.4	1.671616	-0.01323	-0.00912	2.4	0.603623	-0.04322	-0.01046	1.4	1.458965	0.015417
5	1968	1.146484	-0.02207	-0.01919	1.5	2.149643	-0.011	-0.00802	2.8	0.691392	0.034182	0.006907	1	1.611173	0.000435
6	1969	1.105378	0.009857	0.01035	1.6	1.896451	0.021183	-0.00694	2.2	0.791338	0.028234	0.008881	0.6	1.786585	0.016344
7	1970	1.048611	-0.00292	-0.01547	1.1	1.955069	0.008119	-0.00278	1.8	0.901961	0.064396	-0.00249	0.5	1.970261	0.029511
8	1971	0.994047	0.045716	0.028656	1	2.224578	0.029773	0.01221	1.7	1.015923	-0.04473	-0.0031	0.6	2.214513	0.026407
9	1972	0.944235	-0.01597	-0.02081	0.9	2.841953	0.023591	0.016398	2.2	1.173127	-0.01944	0.002379	0.8	2.451621	-0.02429
10	1973	0.911867	0.022597	0.016598	0.8	2.657136	-0.00723	0.000652	2.2	1.355442	0.022404	0.003182	0.8	2.70507	0.006065
11	1974	0.911034	0.006379	-0.00816	1	2.339444	0.044203	-0.00332	2.3	1.632607	-0.00603	-0.00964	1.8	3.105813	0.032016
12	1975	0.9444	-0.01208	0.00729	1.3	3.755017	-0.01821	-0.01366	4.2	1.998726	-0.04248	-0.01371	3.3	3.430829	0.031792
13	1976	1.018756	-0.03452	-0.02243	1.4	4.736334	-0.00913	0.005101	5.5	2.353184	0.008494	0.008374	3.3	3.769761	-0.02109
14	1977	1.139241	-0.01267	-0.0035	1.5	5.534719	-0.06685	-0.02726	6.3	2.783636	-0.01313	-0.0055	3.2	4.089824	-0.00793
15	1978	1.303472	0.003971	0.001082	1.5	6.349228	-0.01675	0.000129	6.8	3.27917	-0.01163	-0.00757	3.2	4.437426	0.000362
16	1979	1.508404	-0.02784	-0.01528	1.4	7.023073	-0.01324	-0.00637	7	3.786956	0.003087	0.006666	2.9	4.603128	-0.02519
17	1980	1.758726	0.008211	0.00307	1.7	7.825515	0.045805	0.027059	7.4	4.315597	0.009882	-0.00293	3	4.87378	-0.00065
18	1981	2.03619	0.011638	-0.00115	2.6	9.968867	-0.03453	0.000461	9.4	4.883625	-0.02011	0.002346	4.3	5.25515	-0.02747
19	1982	2.299139	-0.01792	-0.01474	3.1	11.41584	0.002865	-0.00136	11	5.446342	-0.00699	-0.00457	6.1	5.463334	-0.00962
20	1983	2.533199	-0.01573	-3E-05	3.1	10.74911	-0.01061	0.004945	10.7	5.952456	-0.00768	-0.00165	7.5	5.656457	-0.00398
21	1984	2.74569	0.008967	0.000597	3.3	10.42475	0.011378	-0.00685	10.8	6.347579	-0.00213	-0.00891	7.8	5.80402	-0.03729
22	1985	2.926963	0.000395	0.008804	3.6	9.425948	-0.02575	-0.01543	10.1	6.678495	-0.00533	-0.01569	8	5.914401	-0.00226

– `Method` either `CAM` or `HP`.

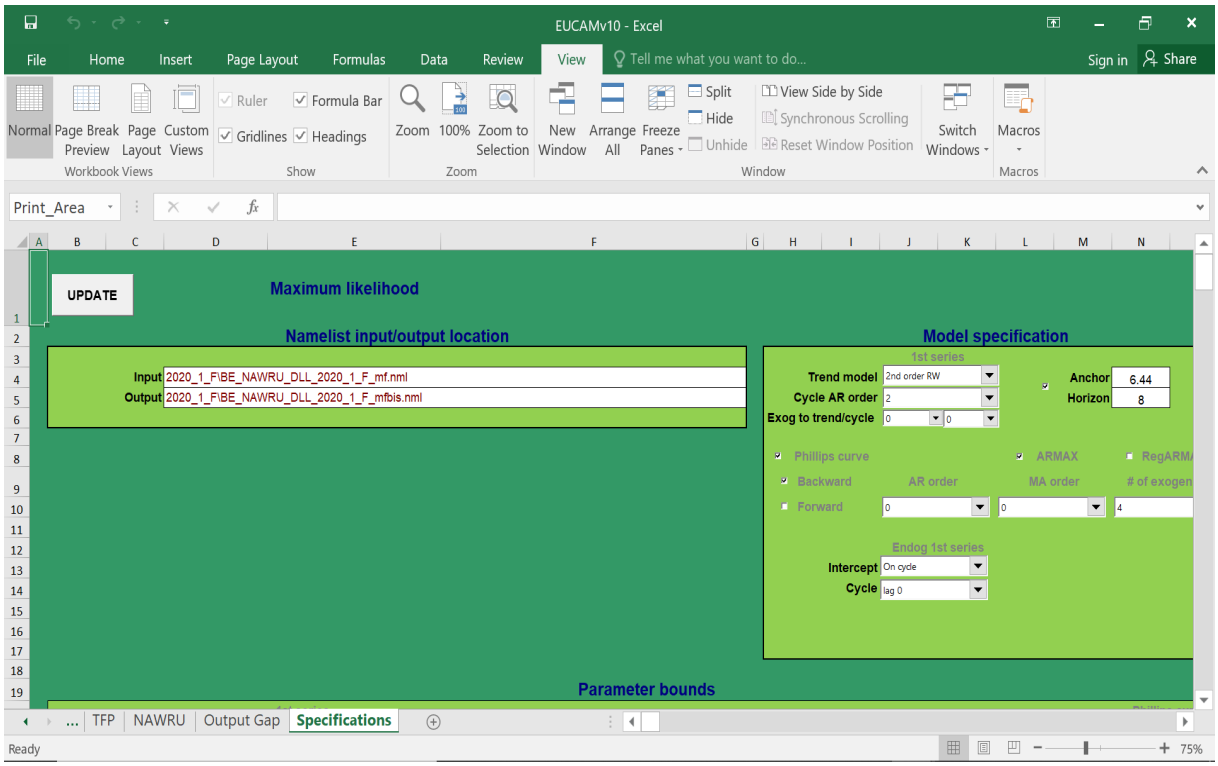
– Press `View` to visualise the model file which contains all information about the model specification.

– Press `Choose` to pick a model file located in the vintage folder: for instance `AT_NAWRU_2020_Autumn_F_mf.nml` contains a model specification for Austria. The selected file appears in column D as shown in Figure 10.

– Press `Bounds` to revise the bounds of the variance parameters - see model (2.10)-(2.11). Use can be made of the information displayed in columns M-N, P-Q, and S-T, where the current variance bounds are reported. The user is first asked to choose the name of the model file which will contain the new bounds.

– Press `Model` to revise the model specification. This action opens the "Specifications" worksheet as shown in Figure 12. The user can choose a model name, change the model specifications, and save the new model file by pressing `Update`.

FIGURE 12 EUCAM Worskheet NAWRU - Interface for updating the model



– Press `RUN` to estimate the NAWRU for each country for which estimation is set to 'Y'.

– Press `Charts` in column `View` to see graphics as illustrated in Figure 13. Six panels are displayed:

  – The top-left panel displays the unemployment rate and the NAWRU in the current and previous vintage;

  – The top-right panel shows the unemployment gap in the last two vintages.

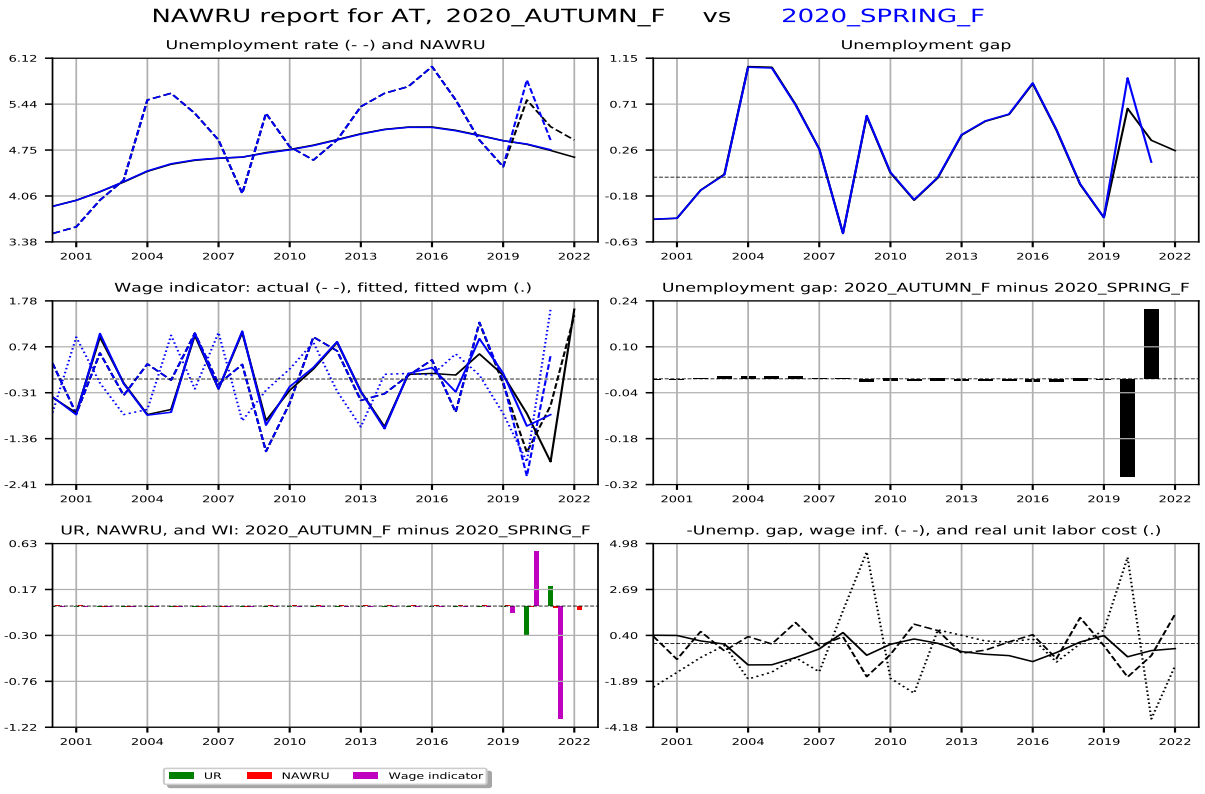
– The mid-left panel shows the labour cost indicator in the Phillips curve (2.11), change in wage inflation in the case of AT, together with its 'fitted' component which refers to its explained component, i.e. the component of the labour cost indicator which is common to unemployment. The fitted values obtained by applying the previously used model to the new vintage is also displayed in dots - label 'wpm'.

– The mid-right panel shows the revisions to the unemployment gap compared to the previous vintage in the last years.

– The bottom-left panel displays the revisions to the unemployment rate, the NAWRU, and the wage indicator compared to the previous vintage in the last years.

– The bottom-right panel shows the unemployment gap times its coefficient ($\beta < 0$) in (2.11) together with the labour cost indicator.

FIGURE 13 EUCAM Worskheet NAWRU - Charts




```
2020_AUTUMN_F : Beta t-stat = -1.47
.                LB        UB
Slope var.    0.01      0.1
Trend var.    1e-08      0.05
Cycle var.    0.07      0.15

2020_SPRING_F : Beta t-stat = -1.64
.                LB        UB
Slope var.    0.01      0.1
Trend var.    1e-08      0.05
Cycle var.    0.07      0.15
```

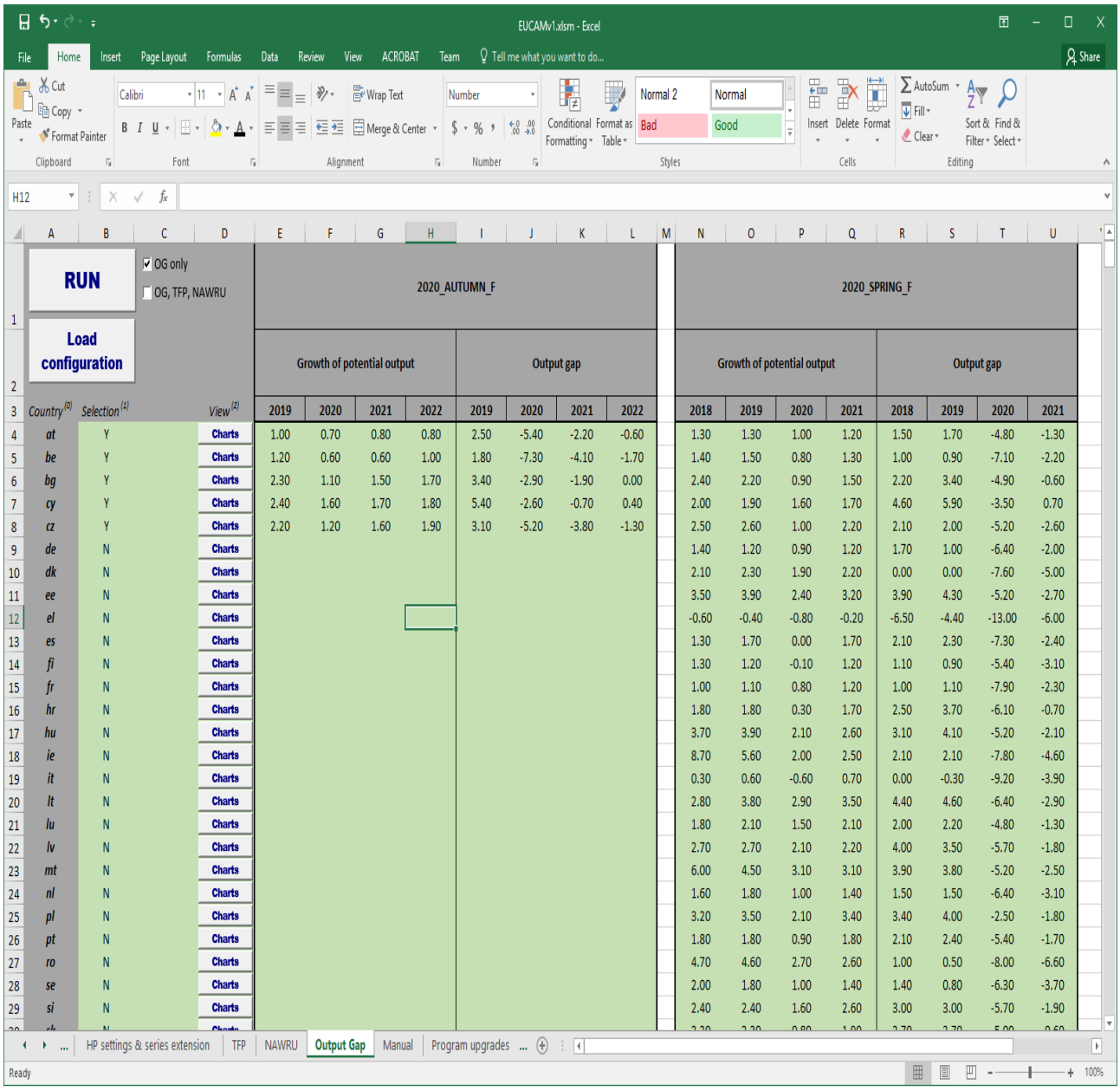
EUCAM v1 (2021-04-29 09:53:15)

– Press `Results` to see the `SOL.txt` file that contains the maximum likelihood parameter estimates. The estimated value of a selection of parameters is reported from columns L onward.

3.2.5 Worksheet Output Gap

The worksheet Output Gap displays the Potential Growth and Output Gap estimates.

FIGURE 14 EUCAM Worskheet Output Gap



EUCAMv1.xlsm - Excel

RUN

Load configuration

OG only

OG, TFP, NAWRU

				2020_AUTUMN_F								2020_SPRING_F							
				Growth of potential output				Output gap				Growth of potential output				Output gap			
Country(0)	Selection(1)		View(2)	2019	2020	2021	2022	2019	2020	2021	2022	2018	2019	2020	2021	2018	2019	2020	2021
at	Y		Charts	1.00	0.70	0.80	0.80	2.50	-5.40	-2.20	-0.60	1.30	1.30	1.00	1.20	1.50	1.70	-4.80	-1.30
be	Y		Charts	1.20	0.60	0.60	1.00	1.80	-7.30	-4.10	-1.70	1.40	1.50	0.80	1.30	1.00	0.90	-7.10	-2.20
bg	Y		Charts	2.30	1.10	1.50	1.70	3.40	-2.90	-1.90	0.00	2.40	2.20	0.90	1.50	2.20	3.40	-4.90	-0.60
cy	Y		Charts	2.40	1.60	1.70	1.80	5.40	-2.60	-0.70	0.40	2.00	1.90	1.60	1.70	4.60	5.90	-3.50	0.70
cz	Y		Charts	2.20	1.20	1.60	1.90	3.10	-5.20	-3.80	-1.30	2.50	2.60	1.00	2.20	2.10	2.00	-5.20	-2.60
de	N		Charts									1.40	1.20	0.90	1.20	1.70	1.00	-6.40	-2.00
dk	N		Charts									2.10	2.30	1.90	2.20	0.00	0.00	-7.60	-5.00
ee	N		Charts									3.50	3.90	2.40	3.20	3.90	4.30	-5.20	-2.70
el	N		Charts									-0.60	-0.40	-0.80	-0.20	-6.50	-4.40	-13.00	-6.00
es	N		Charts									1.30	1.70	0.00	1.70	2.10	2.30	-7.30	-2.40
fi	N		Charts									1.30	1.20	-0.10	1.20	1.10	0.90	-5.40	-3.10
fr	N		Charts									1.00	1.10	0.80	1.20	1.00	1.10	-7.90	-2.30
hr	N		Charts									1.80	1.80	0.30	1.70	2.50	3.70	-6.10	-0.70
hu	N		Charts									3.70	3.90	2.10	2.60	3.10	4.10	-5.20	-2.10
ie	N		Charts									8.70	5.60	2.00	2.50	2.10	2.10	-7.80	-4.60
it	N		Charts									0.30	0.60	-0.60	0.70	0.00	-0.30	-9.20	-3.90
lt	N		Charts									2.80	3.80	2.90	3.50	4.40	4.60	-6.40	-2.90
lu	N		Charts									1.80	2.10	1.50	2.10	2.00	2.20	-4.80	-1.30
lv	N		Charts									2.70	2.70	2.10	2.20	4.00	3.50	-5.70	-1.80
mt	N		Charts									6.00	4.50	3.10	3.10	3.90	3.80	-5.20	-2.50
nl	N		Charts									1.60	1.80	1.00	1.40	1.50	1.50	-6.40	-3.10
pl	N		Charts									3.20	3.50	2.10	3.40	3.40	4.00	-2.50	-1.80
pt	N		Charts									1.80	1.80	0.90	1.80	2.10	2.40	-5.40	-1.70
ro	N		Charts									4.70	4.60	2.70	2.60	1.00	0.50	-8.00	-6.60
se	N		Charts									2.00	1.80	1.00	1.40	1.40	0.80	-6.30	-3.70
si	N		Charts									2.40	2.40	1.60	2.60	3.00	3.00	-5.70	-1.90

HP settings & series extension | TFP | NAWRU | Output Gap | Manual | Program upgrades

Ready

- Press `RUN` to build the new Output Gap estimates. Depending on which box is ticked, `OG only` or `OG, TFP, NAWRU`, also the potential TFP and the NAWRU are recalculated, otherwise used is made of the last estimates. Columns E-H displays potential growth from T-1 to T+2 and columns I-L the respective output gap estimates. Columns N to U reports the values obtained with the previous vintage.

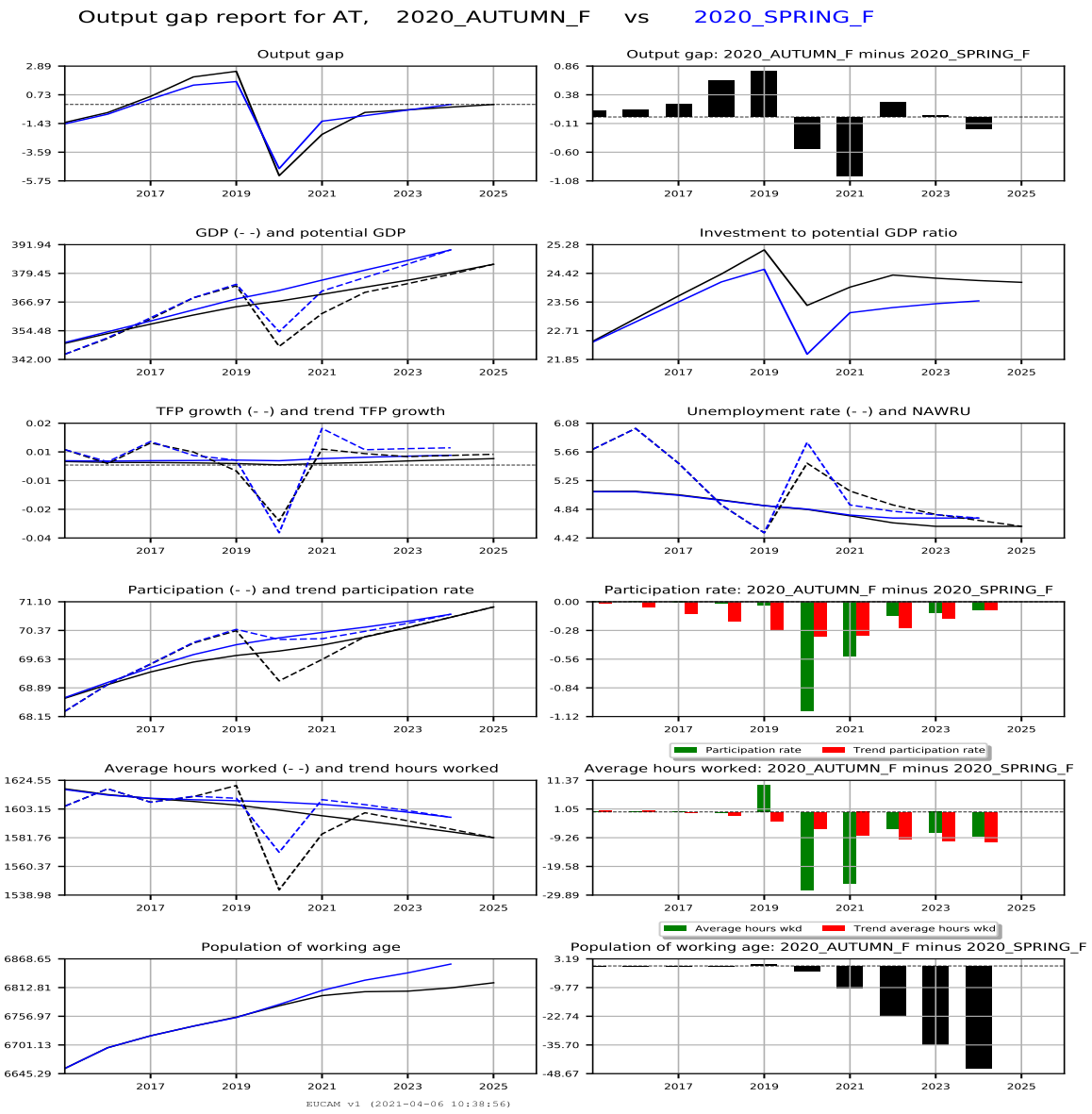
- Press `Charts` to see graphics as illustrated in Figure 15. Twelve panels are displayed:

  - The first-left panel shows the output gap in the current and previous vintages.
  - The first-right panel shows the revisions in output gap between the current and the previous vintage.
  - The second-left panel shows GDP and potential GDP in the current against the previous vintage.
  - The second-right panel shows investment to potential for the current and previous vintage.
  - The third-left panel displays the current and previous vintages of TFP and trend TFP.
  - The third-right panel shows Unemployment and NAWRU in the current against the previous vintage.
  - The fourth-left panel shows the participation rate and its trend in the current and previous vintages.
  - The fourth-right panel shows the revisions in the current vintage of participation rate and trend participation rate.
  - The fifth-left panel shows average hours worked and its trend in the current and previous vintages.
  - The fifth-right panel shows the revisions in the current vintage of hours worked.
  - The sixth-left panel shows population of working age in the current and previous vintages.

  - The sixth-right panel shows the revisions in the current current vintage of population of working age.

- Press `Load configuration` to load the settings saved in a previous work session, for instance with a different data vintage. The configuration is written in the file `Configurationfile.nml` which contains all the settings introduced in the Excel interface. The program overwrites the file `Configurationfile.nml` at each execution.

FIGURE 15 EUCAM Worskheet Output Gap - Charts



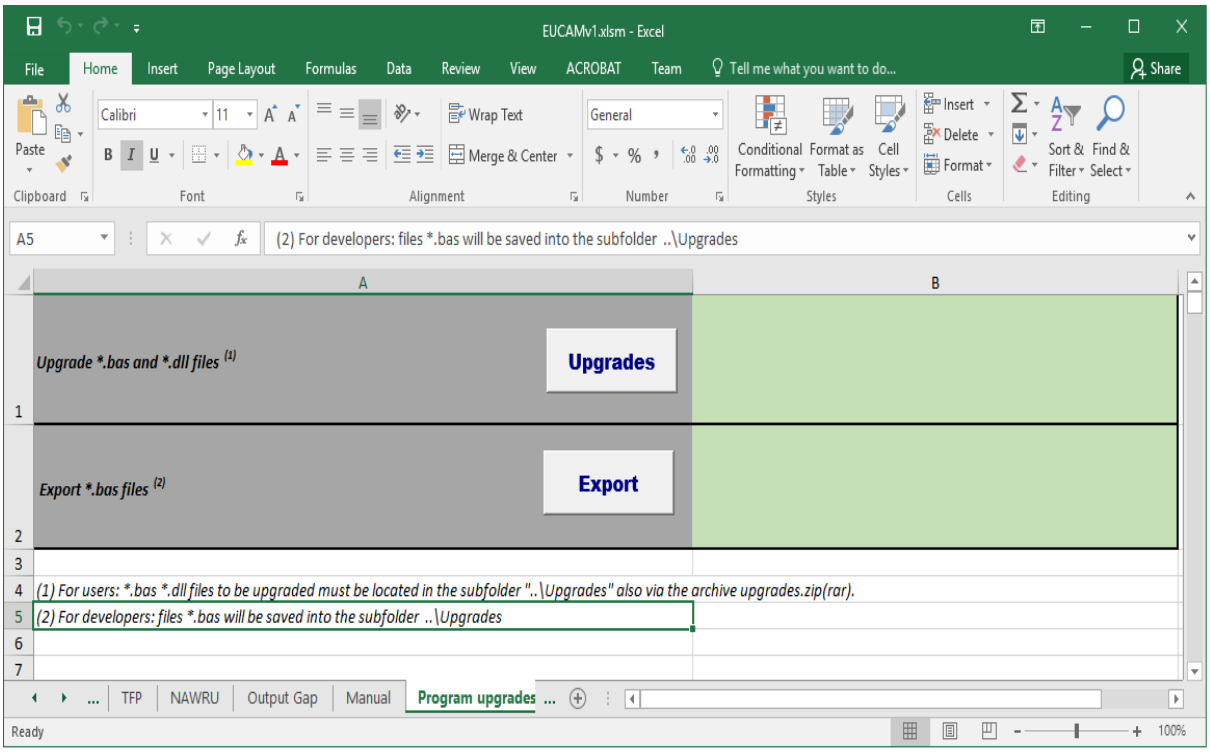
3.2.6 Worksheet Manual

The worksheet Manual contains the links to open the EUCAM and GAP manuals.

3.2.7 Worksheet Upgrades

The worksheet Upgrades allows users to easily upgrade the EUCAM software. The updated program files `upgrades.zip` or `upgrades.rar` must be downloaded from the CIRCA website and written in the folder `C:\EUCAM\Upgrades`. EUCAM is then updated by simply pressing the button `Upgrades` (see Figure 16). The new files (with extension `*.bas`, `*.dll`, and `*.exe`) overwrite the existing ones.

FIGURE 16 EUCAM Worksheet Program upgrades



Conversely, pressing `Export` saves the Visual Basic routines `*.bas` that are incorporated in the EUCAM Excel file into the folder `C:\EUCAM\Upgrades`.

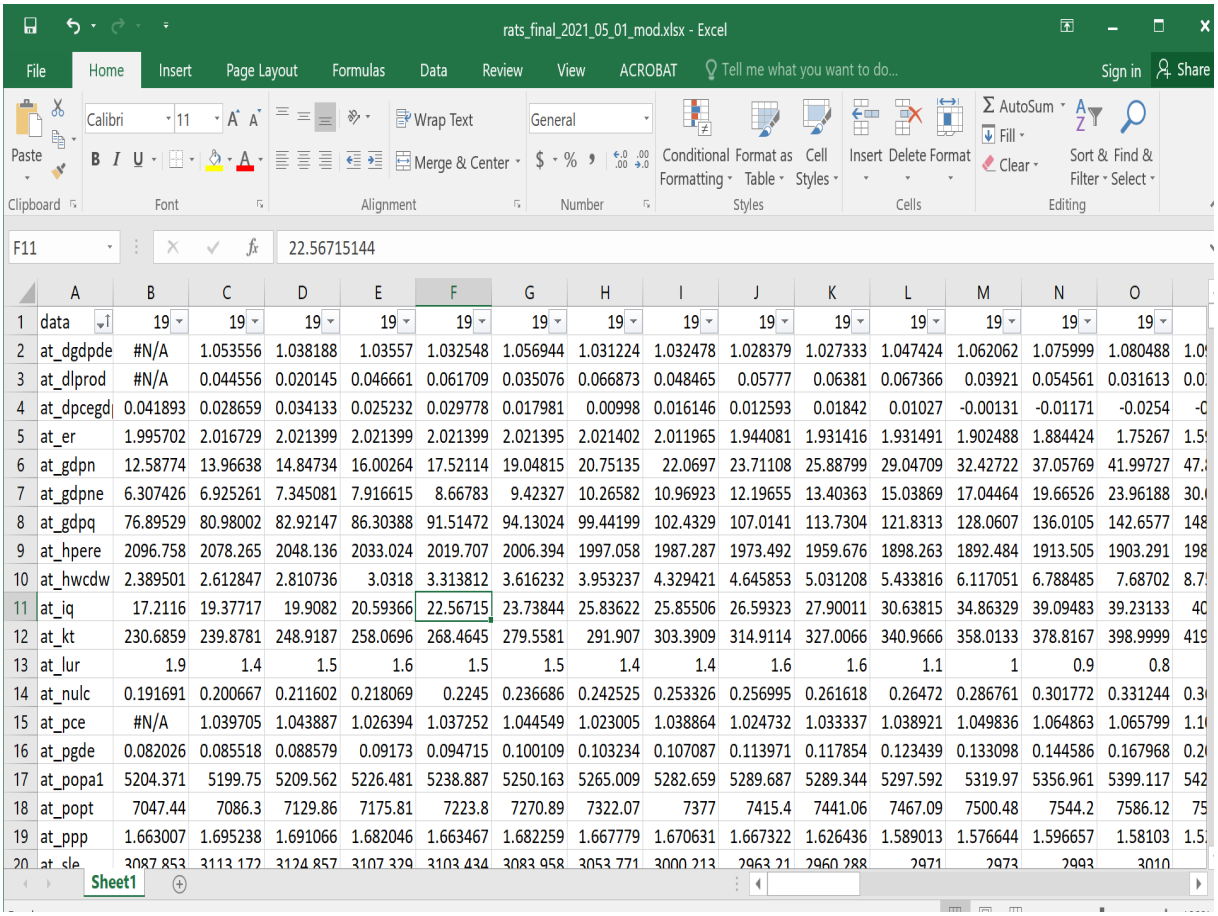
4 Data description

This Section describes the data involved in the EUCAM. Three sources are used: AMECO, the DG ECFIN Business and Consumer surveys, and Eurostat.

4.1 AMECO

Most of the data come from AMECO. The AMECO database collects national accounts data from either the national institutions, Eurostat, or the OECD. The AMECO data are distributed in an Excel file together with EUCAM. A typical AMECO data file is illustrated in Figure 17. Each row starting with the label 'co_x' contains data about variable 'x' in country 'co'. The acronyms used in the data file and their correspondence with AMECO codes are displayed in Table A. Further details can be found in Appendix A.

FIGURE 17 Example of AMECO data file



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	data	19	19	19	19	19	19	19	19	19	19	19	19	19	19
2	at_dgdpde	#N/A	1.053556	1.038188	1.03557	1.032548	1.056944	1.031224	1.032478	1.028379	1.027333	1.047424	1.062062	1.075999	1.080488
3	at_dlprod	#N/A	0.044556	0.020145	0.046661	0.061709	0.035076	0.066873	0.048465	0.05777	0.06381	0.067366	0.03921	0.054561	0.031613
4	at_dpcegd	0.041893	0.028659	0.034133	0.025232	0.029778	0.017981	0.00998	0.016146	0.012593	0.01842	0.01027	-0.00131	-0.01171	-0.0254
5	at_er	1.995702	2.016729	2.021399	2.021399	2.021399	2.021395	2.021402	2.011965	1.944081	1.931416	1.931491	1.902488	1.884424	1.75267
6	at_gdpn	12.58774	13.96638	14.84734	16.00264	17.52114	19.04815	20.75135	22.0697	23.71108	25.88799	29.04709	32.42722	37.05769	41.99727
7	at_gdpne	6.307426	6.925261	7.345081	7.916615	8.66783	9.42327	10.26582	10.96923	12.19655	13.40363	15.03869	17.04464	19.66526	23.96188
8	at_gdpq	76.89529	80.98002	82.92147	86.30388	91.51472	94.13024	99.44199	102.4329	107.0141	113.7304	121.8313	128.0607	136.0105	142.6577
9	at_hpere	2096.758	2078.265	2048.136	2033.024	2019.707	2006.394	1997.058	1987.287	1973.492	1959.676	1898.263	1892.484	1913.505	1903.291
10	at_hwcdw	2.389501	2.612847	2.810736	3.0318	3.313812	3.616232	3.953237	4.329421	4.645853	5.031208	5.433816	6.117051	6.788485	7.68702
11	at_iq	17.2116	19.37717	19.9082	20.59366	22.56715	23.73844	25.83622	25.85506	26.59323	27.90011	30.63815	34.86329	39.09483	39.23133
12	at_kt	230.6859	239.8781	248.9187	258.0696	268.4645	279.5581	291.907	303.3909	314.9114	327.0066	340.9666	358.0133	378.8167	398.9999
13	at_lur	1.9	1.4	1.5	1.6	1.5	1.5	1.4	1.4	1.6	1.6	1.1	1	0.9	0.8
14	at_nulc	0.191691	0.200667	0.211602	0.218069	0.2245	0.236686	0.242525	0.253326	0.256995	0.261618	0.26472	0.286761	0.301772	0.331244
15	at_pce	#N/A	1.039705	1.043887	1.026394	1.037252	1.044549	1.023005	1.038864	1.024732	1.033337	1.038921	1.049836	1.064863	1.065799
16	at_pgde	0.082026	0.085518	0.088579	0.09173	0.094715	0.100109	0.103234	0.107087	0.113971	0.117854	0.123439	0.133098	0.144586	0.167968
17	at_popa1	5204.371	5199.75	5209.562	5226.481	5238.887	5250.163	5265.009	5282.659	5289.687	5289.344	5297.592	5319.97	5356.961	5399.117
18	at_popt	7047.44	7086.3	7129.86	7175.81	7223.8	7270.89	7322.07	7377	7415.4	7441.06	7467.09	7500.48	7544.2	7586.12
19	at_ppp	1.663007	1.695238	1.691066	1.682046	1.663467	1.682259	1.667779	1.670631	1.667322	1.626436	1.589013	1.576644	1.596657	1.58103
20	at_sle	3087.853	3113.172	3124.857	3107.329	3103.434	3083.958	3053.771	3000.213	2963.21	2960.288	2971	2973	2993	3010

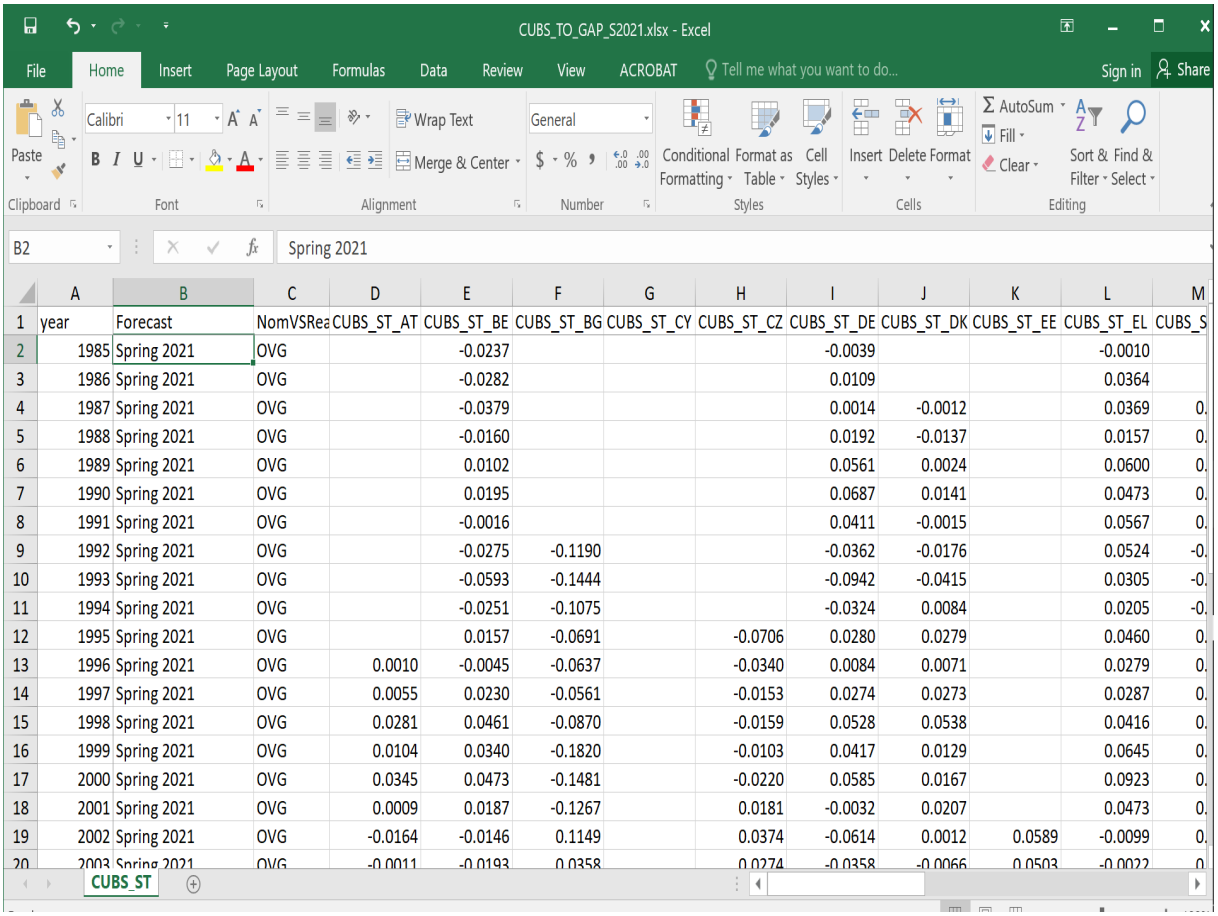
Table A List of variables with correspondences

Name in data file	AMECO	Description	Formula
dgdpdef	PVGD	GDP def. % change	(A3)
dlprod	RVGDE	Change in productivity	(2.11), (A1)
dpcegdp		log(Private consumption def/GDP def)	
er	XNE	Exchange rate	Output data
gdpn	UVGD	Nominal GDP	Output data
gdpne	UVGD	Nominal GDP in euro	Output data
gdpq	OVGD	Real GDP	(2.14)
hpere	NLHA	Hours worked per employee	(2.4), (2.6)
hwcdw	HWCDW	Nominal compensation	(A3)
		per employee	
iq	OIGT	Real gross fixed capital formation	(2.12)
kt	OKND	Capital stock	(2.12)
lur	ZUTN	Harmonised unemployment rate	(2.4), (2.10)
nulc	PLCD	Nominal unit labour cost	
pce dpce	PCPH	Private consumption	(A3)
		expenditure deflator, % change	(A3)
pgde	PVGD	GDP def. (euro)	Output data
popa1	NPAN1	Working age population (15-74)	(2.4)
popt	NPTD	Total population	Output data
ppp	KNP	Purchasing power parity	Output data
sle	NECN	Employment, civilian	Output data
sle1	NETN	Employment, national	(2.22)
sled	NETD	Employment, domestic	(2.7), (2.22)
winf	HWCDW	Wage inflation	(2.11)
ws	UWCD	Wage share	(2.11)

4.2 CUBS data

The CUBS series which are used to detrend TFP series are distributed in the CUBS file, whose format is illustrated in Figure 18. CUBS is a composite indicator of capacity utilisation calculated using DG ECFIN data from Business and Consumer surveys. A detailed description can be found in Annex 3 of Havik et al. (2014).

FIGURE 18 Example of Capacity Utilisation data file



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	year	Forecast	NomVSRea	CUBS_ST_AT	CUBS_ST_BE	CUBS_ST_BG	CUBS_ST_CY	CUBS_ST_CZ	CUBS_ST_DE	CUBS_ST_DK	CUBS_ST_EE	CUBS_ST_EL	CUBS_S
2	1985	Spring 2021	OVG		-0.0237				-0.0039			-0.0010	
3	1986	Spring 2021	OVG		-0.0282				0.0109			0.0364	
4	1987	Spring 2021	OVG		-0.0379				0.0014	-0.0012		0.0369	0.
5	1988	Spring 2021	OVG		-0.0160				0.0192	-0.0137		0.0157	0.
6	1989	Spring 2021	OVG		0.0102				0.0561	0.0024		0.0600	0.
7	1990	Spring 2021	OVG		0.0195				0.0687	0.0141		0.0473	0.
8	1991	Spring 2021	OVG		-0.0016				0.0411	-0.0015		0.0567	0.
9	1992	Spring 2021	OVG		-0.0275	-0.1190			-0.0362	-0.0176		0.0524	-0.
10	1993	Spring 2021	OVG		-0.0593	-0.1444			-0.0942	-0.0415		0.0305	-0.
11	1994	Spring 2021	OVG		-0.0251	-0.1075			-0.0324	0.0084		0.0205	-0.
12	1995	Spring 2021	OVG		0.0157	-0.0691		-0.0706	0.0280	0.0279		0.0460	0.
13	1996	Spring 2021	OVG	0.0010	-0.0045	-0.0637		-0.0340	0.0084	0.0071		0.0279	0.
14	1997	Spring 2021	OVG	0.0055	0.0230	-0.0561		-0.0153	0.0274	0.0273		0.0287	0.
15	1998	Spring 2021	OVG	0.0281	0.0461	-0.0870		-0.0159	0.0528	0.0538		0.0416	0.
16	1999	Spring 2021	OVG	0.0104	0.0340	-0.1820		-0.0103	0.0417	0.0129		0.0645	0.
17	2000	Spring 2021	OVG	0.0345	0.0473	-0.1481		-0.0220	0.0585	0.0167		0.0923	0.
18	2001	Spring 2021	OVG	0.0009	0.0187	-0.1267		0.0181	-0.0032	0.0207		0.0473	0.
19	2002	Spring 2021	OVG	-0.0164	-0.0146	0.1149		0.0374	-0.0614	0.0012	0.0589	-0.0099	0.
20	2003	Spring 2021	OVG	-0.0011	-0.0193	0.0358		0.0274	-0.0358	-0.0066	0.0503	-0.0022	0.

4.3 Population

Two series, namely population of working age POPAF and total population POPTF, are used to extend the population series. The format of the input file is illustrated in Figure 19

while the abbreviations are explained in Table B.

FIGURE 19 Example of Population data file

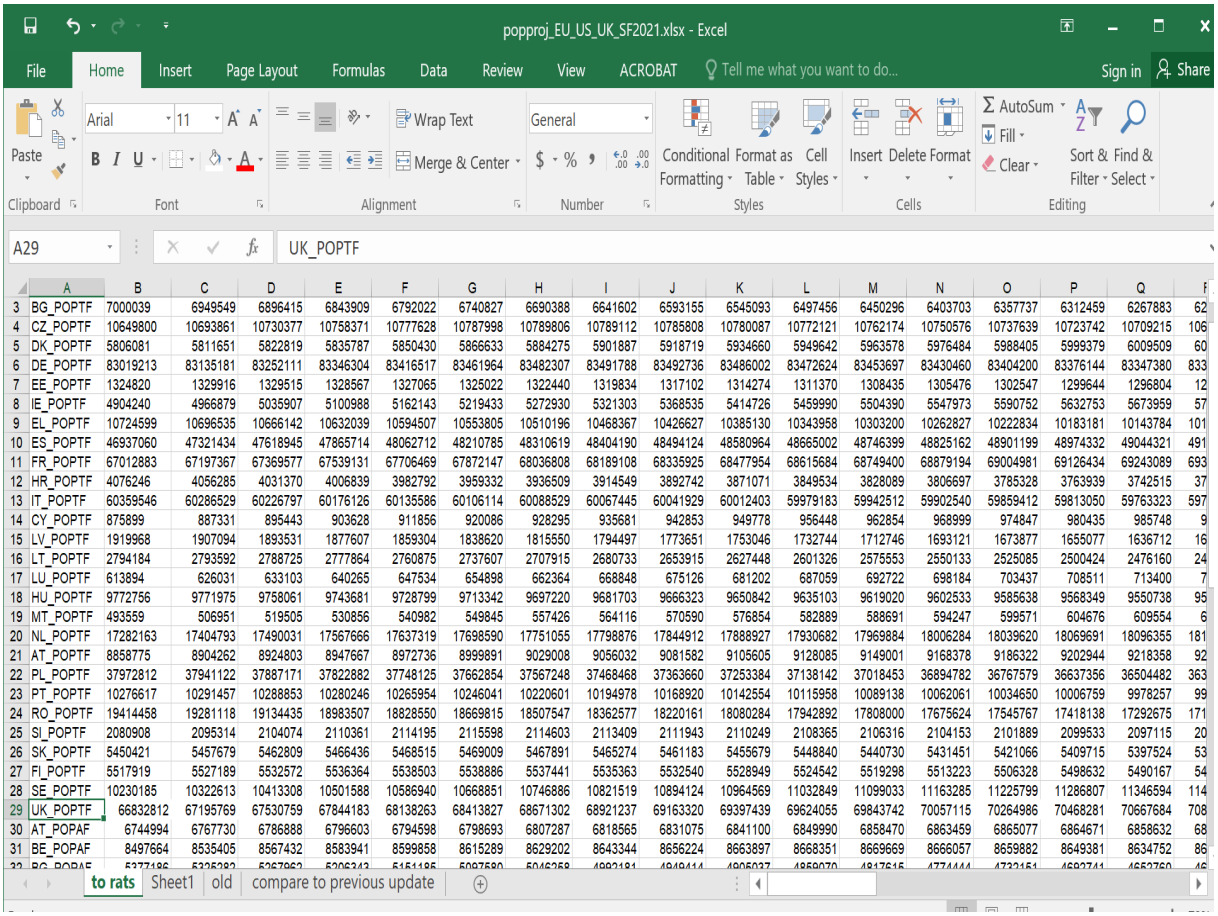


Table B Population variables with correspondences

Name in data file	Eurostat	Description	Formula
POPAF	proj_18np	Projection for working age population (15-74)	(2.19)
POPTF	proj_18np	Projection for total population	(2.19)

5 Conclusion

The EUCAM software implements the methodology commonly agreed between EU Member States to estimate potential growth and the output gap. All operations are integrated in a user-friendly environment which offers several facilities like multi-country analysis and graphical comparisons using another data vintage. The program is open-source and can be downloaded from CIRCABC together with the data files.

Appendix A AMECO data & acronyms

Compensation of employees

- UWCD: total economy.
  Note: domestic concept, included are residents as well as non-residents working for resident producer units. Compensation of employees includes wages and salaries and employers' social contributions.

UWCD is used for calculating the labour cost indicator (A2) or (A3) which appears in the Phillips curve (2.11).

Consumption of fixed capital at current prices

- UKCT: total economy.

UKCT is used to measure capital.

Employment (1000 persons)

- NECN: Civilian employment.
  Note: Civilian employment is equivalent to civilian labour force NLCN minus total unemployment ZUTN. Civilian employment according to the national concept includes residents who work for resident as well as non-resident producer units.
- NETN: national, total economy.
- NETD: all domestic industries, total economy.
  Note: NETD is a domestic concept, included are residents as well as non-residents who work for resident producer units. Employment covers employees and self-employed persons. Annual average.
- FETD = domestic, full time equivalent, total economy.

– NWTD: all domestic industries excluding self-employed workers, total economy.

– FWTD: full-time equivalents; total economy.

NETN is used as number of employees when calculating labour in (2.4).

Gross domestic product at market prices

– UVGD: at current prices, total economy.

– OVGD: at constant prices, total economy.

– PVGD: price deflator calculated as 100 × UVGD/OVGD.

OVGD is used to derive the Solow residual in (2.13) and the output gap in (2.3).

Gross domestic product at market prices per hours worked

– NLHA: Average annual hours worked per person employed.

– NLHT : Total hours worked.

Hours worked per employee is one component of total labour in (2.4).

Gross domestic product at market prices per person employed

– RVGDE is calculated in constant prices either as:

$$\begin{aligned} RVGDE &= 1000 \times OVGD/NETD \\ \text{or} &= 1000 \times OVGD/FETD \end{aligned} \tag{A1}$$

RVGDE is used for the calculation of real unit labour costs in (A2)-(2.11).

Gross fixed capital formation at constant prices

– OIGT: total economy.

– PIGT: price deflator, total economy.

Net capital stock at constant prices

– OKND: total economy (OKND_{t-1}+OIGT_t-100 $\times$ $\text{UKCT}_t/\text{PIGT}_t$).

Nominal unit labour cost

– PLCD: total economy.

$$PLCD_t \;=\; 100 \times \frac{(UWCD_t/NWTD_t)/(OVGD_t/NETD_t)}{(UWCD_{95}/NWTD_{95})/(OVGD_{95}/NETD_{95})}$$

Nominal compensation per employee

– HWCDW: total economy, equal to either 1000 $\times$ UWCD/NWTD or to 1000 $\times$ UWCD/FWTD.

HWCDW is involved in the calculation of real unit labour in (A2).

Population

– NPTD: total, annual average.

– NPAN1: 15-74 years.

Working age population helps calculating the participation rate in (2.7).

Private final consumption expenditures

– UCPH: current prices.

– OCPH: constant prices.

– PCPH: Price deflator (100×UCPH/OCPH)
Note: private final consumption expenditure refers to the expenditure on consumption of goods and services of households and non-profit institutions serving households. Goods and services financed by the government and supplied to households as social transfers in kind are not included.

PCPH is used in (A3) to obtain terms-of-trade which is one possible explanatory variable in the backward-looking Phillips curve (2.11).

Real unit labour cost

– The growth rate of real unit labour cost is calculated as:

$$\Delta RULC_t = (HWCDW_t/HWCDW_{t-1} - 1) - \Delta RVGDE_t - (\Delta ZCPIH_t - 1) \tag{A2}$$

where $ZCPIH_t$ is the harmonized consumer price index.

Real unit labour cost appears as endogenous variable in the forward-looking Phillips curve (2.11).

Terms-of-trade

– Terms-of-trade TOT_t is calculated as the difference between the harmonized consumer price index $ZCPIH_t$ and the GDP deflator $PVGD_t$, i.e. $TOT_t = ZCPIH_t - PVGD_t$. The second-order derivative involved in (2.11) is calculated as:

$$ddtot_t = \frac{dpce_t - dgdpdef_t}{dpce_{t-1} - dgdpdef_{t-1}} \tag{A3}$$

where $dpce_t$ and $dgdpdef_t$ denote the first-difference of $ZCPIH$ and $PVGD_t$.

Unemployment

– ZUTN: percentage of civilian labour force; Member States, Source: AMECO.
Note: unemployed persons as a share of the labour force (number of people employed and unemployed, see also ESA 95, paragraph 11.21). For unemployed persons see ZUTN.

Unemployment is used to calculate the participation rate and the NAWRU in (2.7) and (2.10).

Wage inflation

– Wage inflation $WINF$ is calculated using net compensation of employees as in:

$$WINF_t = HWCDW_t/HWCDW_{t-1} - 1 \tag{A3}$$

The change in wage inflation is the endogenous variable in the backward-looking wage Phillips curve (2.11).

Appendix B Output files

Tables B1-B3 describe the variables produced in output. Some variables which are not involved in the EUCAM are produced for internal needs. The output files are named for instance like 'EUCAM_output_2021_Spring_F.xls' (Table B1), 'NAWRU_2021_Spring_F.xls' (Table B2), and 'TFP_2021_Spring_F.xls' (Table B3), and can be found in the vintage folder.

Table B1 Variables in main output file

Y	gross domestic product
Y_GAP	output gap estimated using EUCAM
Y_Pot	potential output
Part	participation rate
Part_S	trend participation rate
wSR	growth of TFP
wSR_KF	growth of potential TFP
NAWRU	non-accelerating wage rate of unemployment
UnEmpl_Rate	unemployment rate
HperE	hours worked per employee
Investment	investment
Pot_LF	potential labour force
Pot_Empl	potential employment
Pot_Tot_Hrs	potential total hours
Empl	employment
Tot_Hrs	total hours
Capital	capital
Wage_Infl	wage inflation
Civ_Empl	civil employment
Pop_WA	population of working age
Tot_Pop	total population
SR	TFP (solow residual)
SR_HP	HP filtered TFP
SR_Kf	Potential TFP
Depreciation	depreciation rate
Exchange rate	exchange rate
PPS	purchase power standard
GDP deflator	GDP deflator
Nominal_GDP-e	nominal GDP in euro
NULC	nominal unit labour cost
endo_dwinf	wage indicator used in NAWRU estimation
fitted_values	fitted wage Phillips curve
CUBS	capacity utilisation indicator
hperehp	hours worked per employee, HP-trend
whperehp	growth of HP-filtered hours worked per employee

Table B2 NAWRU data file

NAWRU	non-accelerating wage inflation rate of unemployment
endo_dwinf	wage indicator used in NAWRU estimation (first difference of wage inflation)
endo_drulc	wage indicator used in NAWRU estimation (first difference of real unit labour cost)
fitted_values	fitted wage Phillips curve
UnEmpl_Rate	unemployment rate

Table B3 TFP data file

cubs	CUBS indicator used to detrend TFP
fitted_values	fitted CUBS
cu_ext	forecasted CUBS
sr	Solow residual
tfpf	forecasted Solow residual
srkf	trend of Solow residual

Appendix C The Hodrick-Prescott filter

The Hodrick-Prescott filter decomposes an observed series x_t into a trend p_t plus an independent noise u_t as in $x_t = p_t + u_t$ by minimising the loss function:

$$\min_{p_1,\cdots,p_T} \sum_{t=1}^{T} u_t^2 + \lambda \sum_{t=3}^{T} (\Delta^2 p_t)^2$$

where Δ denotes first-difference and λ is the inverse signal to noise ratio , for instance 1/100 for yearly data (Hodrick and Prescott, 1997). Harvey and Jaeger (1993) show that the HP filter is a minimum mean square error filter for the I(2) plus noise model below which is thus implicit in HP-detrending:

$$\begin{aligned} x_t &= p_t + u_t \\ \Delta^2 p_t &= a_{pt} \qquad \lambda = V(a_{ut})/V(p_t) \end{aligned}$$

Appendix D The autoregressive model

In order to mitigate end effects, the HP-filter is applied on series extended with forecasts. These forecasts are obtained fitting an autoregressive model such as:

$$x_t = \mu + \gamma_1 x_{t-1} + \cdots + \gamma_p x_{t-p} + e_t$$

where e_t is a white noise. The coefficients are estimated by least-squares given the first p observations.

References

Hristov A., Planas C., Roeger W. and Rossi A. (2017), " NAWRU estimation using structural labour market indicators", European Economy Discussion Papers, no. 69, European Commission: Brussels.

Hristov A. and Roeger W. (2020),"The natural rate of unemployment and its institutional determinants", Quarterly Report on the Euro Area, Directorate General Economic and Financial Affairs, European Commission, vol. 19(1), pp. 67-85.

Havik K., McMorrow K., Orlandi F., Planas C., Raciborski R., Roeger W., Rossi A., Thum-Thyssen A., Vandermeulen V. (2014), "The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps", European Commission, Economic Paper 535.

Juillard, M. (1996), "Dynare : a program for the resolution and simulation of dynamic models with forward variables through the use of a relaxation algorithm", CEPREMAP Working Papers (Couverture Orange) nr. 9602, CEPREMAP.

Orlandi F. (2012), "Structural unemployment and its determinants in the EU countries", European Economy Economic Paper, No 455, European Commission: Brussels.

Planas C., Roeger W. and Rossi A. (2013), "The information content of capacity utilization for detrending total factor productivity", *Journal of Economic Dynamic and Control*, 37, 577-590.

Planas C. and Rossi A. (2020), "Program GAP Technical Description and User-manual", Publications Office of the European Union, Luxembourg, ISBN 978-92-76-20364-3, doi:10.2760/896629.

EUROPEAN ECONOMY DISCUSSION PAPERS

European Economy Discussion Papers can be accessed and downloaded free of charge from the following address:
https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en?field_eurovoc_taxonomy_target_id_selective=All&field_core_nal_countries_tid_selective=All&field_core_date_published_value[value][year]=All&field_core_tags_tid_i18n=22617.

Titles published before July 2015 under the Economic Papers series can be accessed and downloaded free of charge from:
http://ec.europa.eu/economy_finance/publications/economic_paper/index_en.htm.

GETTING IN TOUCH WITH THE EU

In person
All over the European Union there are hundreds of Europe Direct Information Centres. You can find the address of the centre nearest you at: http://europa.eu/contact.

On the phone or by e-mail
Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696 or
- by electronic mail via: http://europa.eu/contact.

FINDING INFORMATION ABOUT THE EU

Online
Information about the European Union in all the official languages of the EU is available on the Europa website at: http://europa.eu.

EU Publications
You can download or order free and priced EU publications from EU Bookshop at: http://publications.europa.eu/bookshop. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see http://europa.eu/contact).

EU law and related documents
For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu.

Open data from the EU
The EU Open Data Portal (http://data.europa.eu/euodp/en/data) provides access to datasets from the EU. Data can be downloaded and reused for free, both for commercial and non-commercial purposes.

Publications Office
of the European Union