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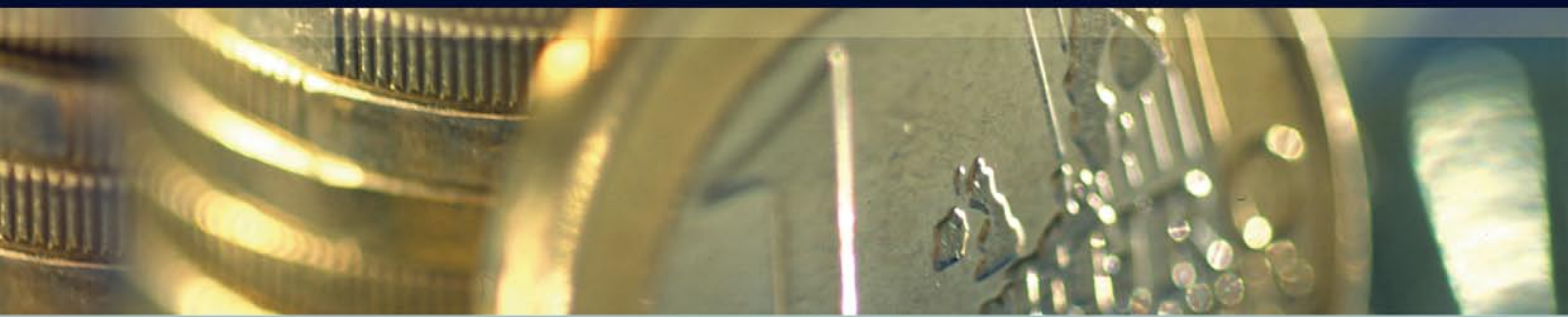

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* The views expressed in this paper are those of the authors and should not be attributed to the European Commission.

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INTRODUCTORY REMARKS

The concepts of potential growth and the output gap form a crucial part of the toolkit for assessing the cyclical position of the economy and its productive capacity. These concepts have become an essential ingredient of the fiscal surveillance process emanating from the Stability and Growth Pact. Potential growth constitutes a summary indicator of the economy's capacity to generate sustainable, non-inflationary, growth whilst the output gap is an indication of the degree of overheating or slack relative to this growth potential.

Estimating the output gap is difficult since potential growth is not directly observable whilst actual GDP is subject to significant historical / forecast revisions. Given the large uncertainty surrounding output gap estimates, due care must be taken in interpreting their size and evolution. Whilst mindful of these uncertainties, the potential growth and output gap forecasts produced by the ECOFIN Council approved production function methodology have been providing essential information to policy makers since their initial release in 2002. This information has been used by policy makers for their ongoing discussions regarding the appropriate mix of macroeconomic and structural policies in the various EU economies, with the former geared to eliminating cyclical slack and the latter being used to raise the output potential of their respective economies.

Given the importance of this work, the EU's Economic Policy Committee has a dedicated working group (i.e. the "Output Gap Working Group" - OGWG) which meets regularly to discuss the operational effectiveness & relevance of the existing production function methodology. The working papers for the discussions in this group are generally prepared by the Commission services (DG ECFIN), although from time to time some papers are presented by non-Commission members of the group. Periodically, the Commission services produce a paper which tries to succinctly summarise the work of the OGWG over a specific period of time, with the present paper updating the last published paper on this topic which appeared in 2006[1].

The present 2010 update coincides of course with one of the most challenging economic periods for many decades, with the eruption and fallout from the financial crisis clearly indicating to policy makers that economic cycles are back with a vengeance. The premature belief amongst many economic commentators during the so-called "Great Moderation" of the late 1990's and the early 21st century that we were witnessing the end of "boom and bust" has been shattered by recent events. As a result of the financial crisis, cyclically corrected indicators have undoubtedly taken on a greater degree of significance and are manifestly back at the forefront of economic policy making. This heightened level of policy interest not only reflects the anxiousness of policy makers to avoid the well-documented mistakes made in assessing the supply side impact of historical crises but is also linked with the primary role of such indicators in calculating cyclically adjusted budget balances & in designing successful "exit strategies" from the current crisis (and especially the requirement to unwind the large increases in EU public debt).

[1] ECFIN Economic Paper No. 247 (2006) “Calculating potential growth rates & output gaps – A revised production function approach ”. This 2006 paper was in turn an update of the ECFIN Economic Paper No. 176 (2002) “Production function approach to calculating potential growth and output gaps : Estimates for the EU Member States and the US”.

1. Concept of Potential Output : Any meaningful analysis of cyclical developments, of medium term growth prospects or of the stance of fiscal and monetary policies are all predicated on either an implicit or explicit assumption concerning the rate of potential output growth. Such pervasive usage in the policy arena is hardly surprising since potential output constitutes the best composite indicator of the aggregate supply side capacity of an economy and of its scope for sustainable, non-inflationary, growth.

Given the importance of the concept, the measurement of potential output is the subject of contentious and sustained research interest. Of course since it is an unobserved variable, before starting to measure it one must firstly clarify exactly what one means by the concept. It signifies different things to different people, especially when discussed over various time horizons, with the concept appreciated differently when placed in a short, medium or long term perspective :

- Over the ***short run***, the physical productive capacity of an economy may be regarded as being quasi fixed and its comparison with the effective / actual output developments (i.e. in output gap analysis) shows by how much total demand can develop during that short period without inducing supply constraints and inflationary pressures.
- Over the ***medium term***, the expansion of domestic demand when it is supported by a strong upturn in the amount of productive investment may endogenously generate the productive output capacity needed for its own support. The latter is all the more likely to occur when profitability is high and is supported by an adequate wage evolution with respect to labour productivity.
- Finally, over the ***long run***, the notion of full employment potential output is linked more to the future evolution of technical progress (or total factor productivity) and to the likely growth rate of labour potential.

These medium and long run considerations should always be kept in mind when discussing potential output since the latter is often seen in an excessively static manner in some policy making fora, where the growth of capacity is often presented as invariant not only in the short run (where such an assumption is warranted) but also over the medium term as if the projection of fixed investment had no impact on productive capacity.

2. Measuring Potential Growth for Use as an Operational Surveillance Tool : Notwithstanding the importance of the concept, and the consequent desire for clarity, the measurement of potential growth is far from straightforward and, being unobservable, can only be derived from either a purely statistical approach or from a full econometric analysis. It is clear however that conducting either type of analysis requires a number of arbitrary choices, either at the level of parameters (in statistical methods) or in the theoretical approach and choice of specifications, data and techniques of estimation (in econometric work).

In other words, all the available methods have "pros" and "cons" and none can unequivocally be declared better than the alternatives in all cases. Thus, what matters is to have a method adapted to the problem under analysis, with well defined limits and, in international comparisons, one that deals identically with all countries. This was the approach which was adopted in the earlier 2002 & 2006 papers on this topic where it was stated clearly that the objective was to produce an economics based, production function, method which could be used for operational EU policy surveillance purposes.

The preference for an economic, as opposed to a statistical, approach was driven by a number of considerations. For example, with an economics based method, one gains the possibility of examining the underlying economic factors which are driving any observed changes in the potential output indicator and consequently the opportunity of establishing a meaningful link between policy reform measures with actual outcomes. An additional advantage of using an economic estimation method is that it is capable of highlighting the close relationship between the potential output and NAIRU concepts, given that the production function (PF) approach requires estimates to be provided of "normal" or equilibrium rates of unemployment. At a wider level, another advantage is the possibility of making forecasts, or at least building scenarios, of possible future growth prospects by making explicit assumptions on the future evolution of demographic, institutional and technological trends.

However, whilst economic estimation would appear to overcome, at least partially, many of the concerns in terms of appraising policy effectiveness which are linked to statistical approaches, on the negative side difficulties clearly emerge with regard to achieving a consensus amongst policy makers on the modelling and estimation methods to be employed. Policy makers are fully aware of these latter trade-offs which make any decision making process, regarding the specific details of the PF approach to calculating potential output, a difficult one to undertake in practice. The PF estimates must therefore be assessed in the light of these predetermined requirements and respect the difficult trade-offs involved.

Since the primary use of the methodology is as an operational surveillance tool in the assessment of the annual stability / convergence programmes of the EU's Member States, it is important that the agreed methodology respects a number of basic principles given the politically sensitive nature of the dossier. As the previous versions of the present paper have stressed, the main operational requirements for the PF approach are as follows :

- Firstly, it has to be a relatively simple and fully transparent methodology where the key inputs and outputs are clearly delineated;

- Secondly, equal treatment for all of the EU's Member States needs to be strictly assured; and

- Finally, given that the estimates are used for budgetary surveillance purposes, it is considered to be important to take a prudent view regarding the assessment of the past and future evolution of potential growth in the EU.

This third requirement of prudence was in fact one of the explicit demands made when policy makers called for a new method to be developed for assessing structural budget balances since it was felt that past surveillance exercises had on a number of occasions produced an excessively optimistic picture of the degree of budgetary improvement in the upswing phase of previous cycles. This "false" optimism was linked to some extent with the cyclicality of the trend GDP estimates which had been calculated using the HP filter statistical method and via which the estimates of structural budget balances had been generated. Consequently, one of the key objectives of replacing the earlier HP methodology was to reduce the degree of cyclicality of the trend growth estimates to an absolute minimum in order to avoid the mistakes of the past. This bias towards a prudent or cautious view is evident in all aspects of the PF estimation process, including in the elaboration of the medium-term extension to the method.

3. Recent modifications to the PF methodology – TFP : Whilst many components of the methodology have been adapted since the previous 2006 version of the paper, the single most important change has undoubtedly been to the TFP methodology. The new TFP method uses a bivariate Kalman Filter (KF) model which exploits the link between the TFP cycle & the degree of capacity utilisation in the economy. This new approach was endorsed by the OGWG and its parent Economic Policy Committee in December 2009, with its formal adoption into the method occurring in the Autumn 2010 forecasting exercise.

The key driving force behind the adoption of the new trend TFP approach has been the persistent concerns, expressed over many years, with the operation of the previous HP filter methodology, with the latter's limitations & problematic nature being particularly exposed during the financial crisis. The basic problem with the existing HP filter method is that such univariate techniques tend to produce imprecise estimates at the end of the sample period (& especially close to turning points / "boom-bust" episodes). Consequently, preliminary HP trend TFP estimates are frequently & sizeably revised over time. Whilst revisions will never be fully eliminated, the new TFP methodology (see detailed description in section 2) will at least constitute an improvement on the existing approach in a number of different respects, including :

- Firstly, compared with the HP filter approach, the KF will lead to less trend TFP revisions, which has important positive gains for policy makers in helping to reduce the degree of uncertainty pertaining to fiscal policy decision making.

- Secondly, it is widely accepted that the KF produces a more realistic pattern for short and medium term trend TFP developments compared with the HP filter. For example, if one compares the results for both approaches over the period of the financial crisis as well as for the expected medium term evolution of trend TFP, one can see some fundamental differences. Since the KF uses the information content from the capacity utilisation series to extract the cyclical TFP component, it suggests firstly that the decline in trend TFP in 2009/2010 will not be as great as that predicted by the HP filter & secondly that the speed of the recovery over the medium term in trend TFP will be much more sluggish compared with the strong, HP filter predicted, rebound. Given the results from alternative estimation methodologies and the evidence from the aftermaths of previous financial crises, the more stable pattern for trend TFP predicted by the KF approach is generally recognised as being more credible than the highly volatile pattern presented by the HP filter.

- Finally, the KF does not suffer to the same extent as the HP filter from the well-documented end-point bias problem since firstly, the capacity utilisation series itself is not revised and secondly, and more importantly, since the KF uses the valuable economic information on the cyclical component of TFP (which it extracts from the capacity utilisation series) to help it produce more accurate forecasts. This is not the case with the HP filter which has no economic information to draw on, with the result that it can be extremely sensitive to the last sample observation. The degree of optimism / pessimism in the last observation can provoke sizeable jumps in the trend TFP series produced by the HP filter, with a real danger that it gives highly misleading signals around turning points (leading of course to large subsequent revisions).

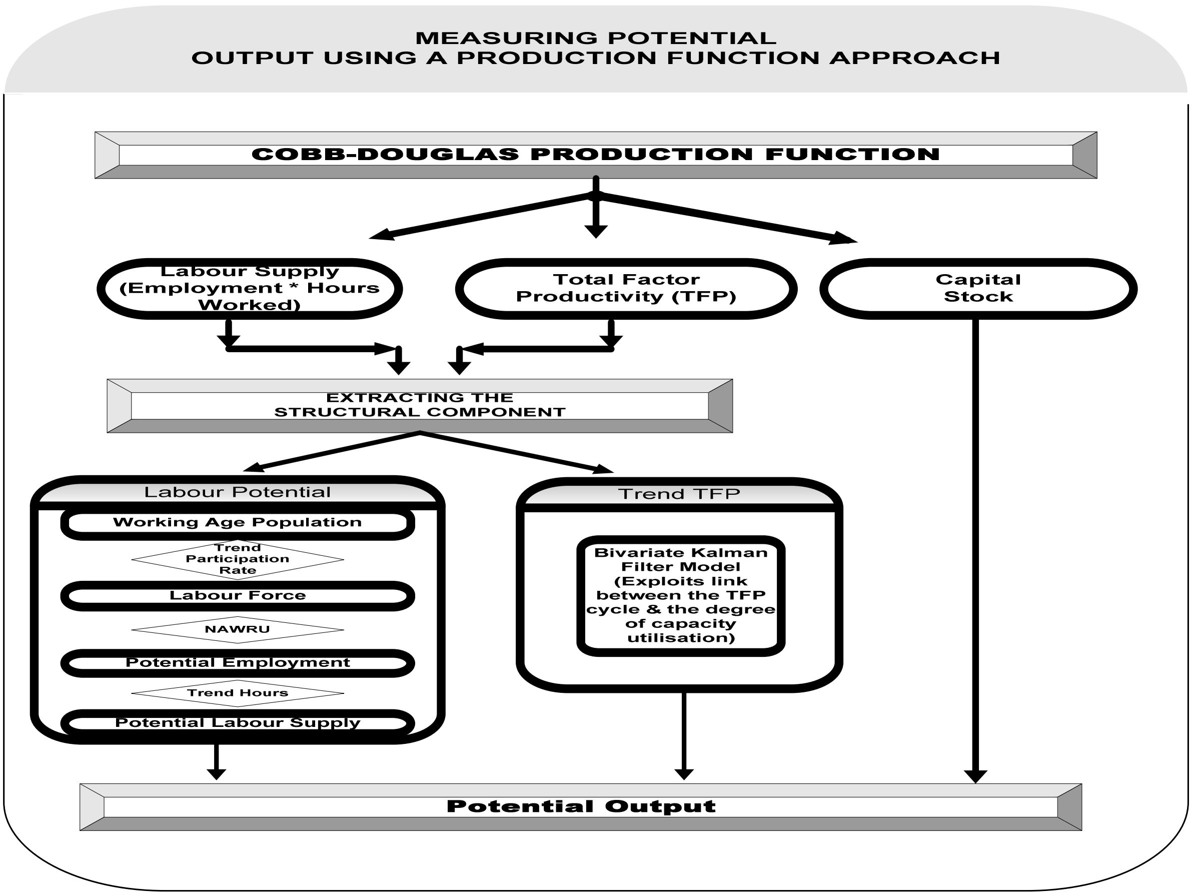
4. Ongoing research work – Capital : A number of ongoing research projects, linked to the capital accumulation component of the PF methodology, are discussed in section 4 of the present paper. For example, work has already been presented to the OGWG on an approach whereby the capital stock can be disaggregated into its housing and non-housing components. As section 4.1 points out, such a disaggregation is entirely feasible, with the preliminary results indicating, however, that there is generally only small effects on potential from such a split since housing investment has a substantially lower rate of return compared with non-housing capital expenditures. In addition, work is presently being undertaken to assess the possibility of deciphering the key structural determinants of capital stock trends, with the objective being to try to isolate "bubbles" in capital spending from long run secular movements. This ongoing research work will be essential in building a consensus amongst the Member States on the need / benefits of possible future changes to the approach. This research agenda is not of course exhaustive, with many other areas of investigation likely to be considered over the coming years based on the practical experience garnered from using the methodology in the regular budgetary surveillance exercises.

5. Structure of Paper : In terms of content, the paper is laid out as follows. Section 1 provides an overview of the PF methodology as it currently operates, with "Box 1" using the method to quantify the impact of the financial crisis on potential. Section 2 goes on to provide a detailed description of the recently approved changes to the TFP component of the methodology, with the previous Hodrick-Prescott filter TFP method being replaced by a Kalman filter (KF) based approach. The gains from such a change, in terms of a reduced level of real time output gap revisions, are discussed in "Box 2". Section 3 focusses on the NAWRU methodology, with its essential features remaining unchanged compared with the description given in the 2006 paper. "Box 3" provides an assessment of the impact of the financial crisis on the NAWRU estimates, including an evaluation of the respective roles of nominal and real rigidities in the labour market adjustment process. Section 4 is devoted to the ongoing research work which is being carried out with respect to the capital accumulation aspect of the method. In the concluding remarks section, there is a discussion on the strengths & limitations of the PF methodology as well as on its essential operating principles. These principles have been strictly adhered to since the formal establishment of the method in 2002 and have inspired all subsequent modifications. Supplementary information is provided in annexes 1-6.

SECTION 1 : A SHORT OVERVIEW OF THE OVERALL PRODUCTION FUNCTION APPROACH

1.1 Main Features of Methodology[2]

Instead of making statistical assumptions on the time series properties of trends and their correlation with the cycle, the production function approach makes assumptions based on economic theory. This latter approach focuses on the supply potential of an economy and has the advantage of giving a more direct link to economic theory but the disadvantage, as explained earlier, is that it requires assumptions on the functional form of the production technology, returns to scale, trend technical progress (TFP) and the representative utilisation of production factors. As shown in the diagram below, with a production function, potential GDP can be represented by a combination of factor inputs, multiplied with the technological level or total factor productivity (TFP). The parameters of the production function essentially determine the output elasticities of the individual inputs, with the trend components of the individual production factors, except capital, being estimated. Since the capital stock is not detrended, estimating potential output amounts therefore to removing the cyclical component from both labour and TFP.



[2] This PF methodology is applicable to all of the "old" EU15 member states, with these 15 countries accepting the use of the PF approach as the reference method for the assessment of their stability and convergence programmes. The HP filter approach is only used as a “back-up” method and only for a short (unfortunately still to be defined) transition period. A modified PF methodology is applicable to all 12 of the ”new” Member States - in parallel with the HP filter approach. This modified PF framework tries to overcome a number of serious statistical problems associated with the availability of only short time series for the new Member States. A common starting date of 1995 was imposed for all 12 countries since too many transitional issues were biasing the pre-1995 data. The main modifications to the methodology, relative to that which applies to the EU15 countries, include firstly, a simpler NAIRU methodology based on wage elasticities (it was not possible to use the more sophisticated Kalman Filter based approach applied to the “old” Member States); secondly, trend TFP is generally estimated using a moving average based, stochastic trend, approach (compared with the proposed new Kalman filter method which will be used for the EU15 countries); and finally, the capital stock is estimated using a capital/output ratio which is fixed in the base year of 1995.

COBB-DOUGLAS PRODUCTION FUNCTION[3] : In more formal terms, with a production function, GDP (Y) is represented by a combination of factor inputs - labour (L) and the capital stock (K), corrected for the degree of excess capacity (U_L, U_K) and adjusted for the level of efficiency (E_L, E_K). In many empirical applications, including the Quest model, a Cobb Douglas specification is chosen for the functional form. This greatly simplifies estimation and exposition. Thus potential GDP is given by:

(1) $$Y = (U_L L\ E_L)^{\alpha}(U_K K E_K)^{1-\alpha} = L^{\alpha} K^{1-\alpha} * TFP$$

where total factor productivity (TFP), as conventionally defined, is set equal to :

(2) $$TFP = (E_L^{\alpha} E_K^{1-\alpha})(U_L^{\alpha} U_K^{1-\alpha})$$

which summarises both the degree of utilisation of factor inputs as well as their technological level. Factor inputs are measured in physical units. An ideal physical measure for labour is hours worked which we use as our labour input. For capital we use a comprehensive measure which includes spending on structures and equipment by both the private and government sectors.

Various assumptions enter this specification of the production function, the most important ones are the assumption of constant returns to scale and a factor price elasticity which is equal to one. The main advantage of these assumptions is simplicity. However these assumptions seem broadly consistent with empirical evidence at the macro level. The unit elasticity assumption is consistent with the relative constancy of nominal factor shares. Also, there is little empirical evidence of substantial increasing / decreasing returns to scale (see, e.g. Burnside et al. for econometric evidence).

The output elasticities of labour and capital are represented by α and $(1-\alpha)$ respectively. Under the assumption of constant returns to scale and perfect competition, these elasticities can be estimated from the wage share. The same Cobb-Douglas specification is assumed for all countries, with the mean wage share for the EU15 over the period 1960-2003 being used as guidance for the estimate of the output elasticity of labour, which would give a value of .63 for α for all Member States and, by definition, .37 for the output elasticity of capital[4]. While the output elasticity for labour may deviate somewhat from the imposed mean coefficient in

[3] **CHOICE OF PRODUCTION TECHNOLOGY – WHY USE COBB-DOUGLAS ?** One of the big advantages of using Cobb-Douglas is undoubtedly its simplicity, in that it is easy to make sense out of the coefficients imposed. The Cobb Douglas assumption greatly simplifies estimation of output elasticities, conditional on an assumption on returns to scale. With a high average degree of competition in the goods market, the output elasticities can be equated to their respective factor shares. Thus, there is only one parameter to estimate. While a large variety of views on alternative specifications to the Cobb-Douglas approach of constant factor shares are available, one needs to be aware of the implications associated with these alternatives. For example, if one chooses to adopt an elasticity of less than 1, one is left with the problem of explaining why wage shares have fallen recently. If one goes for the alternative assumption of using an elasticity of greater than 1, then the lack of econometric evidence to support using such a function needs to be taken into account. Consequently, given the difficulties associated with the alternatives, the Cobb-Douglas assumption of unity appears to be a reasonable compromise. In addition, of course, if one were to use a CES function with an elasticity of 0.8 or 1.2 the results would not differ very strongly from Cobb-Douglas. Finally, the aggregation problem associated with having a mixture of low and high skilled workers in the workforce would also appear to lend support to the Cobb-Douglas view. In this regard, if you aggregate over both sets of workers, one would come close to Cobb-Douglas, with low skilled workers having a high elasticity of substitution (EoS) with capital (EoS > 1) balancing out the low EoS associated with high skilled workers (EoS < 1). High skilled workers have generally a low EoS since such workers are regarded as being more complementary to K. This view regarding the distinction between low and high skilled workers is supported in a paper by Krussell et al. published in *Econometrica* in September 2000.

[4] Since these values are close to the conventional mean values of 0.65 & 0.35, the latter are imposed for all countries.

the case of individual Member States, such differences should not seriously bias the potential output results.

To summarise therefore, in moving from actual to potential output it is necessary to define clearly what one means by potential factor use and by the trend (i.e. normal) level of efficiency of factor inputs.

- **CAPITAL** : With respect to capital, this task of defining potential factor use is straightforward since the maximum potential output contribution of capital is given by the full utilisation of the existing capital stock in an economy. Since the capital stock is an indicator of overall capacity there is no justification to smooth this series in the production function approach. In addition, the unsmoothed series is relatively stable for the EU and the US since although investment is very volatile, the contribution of capital to growth is quite constant since net investment in any given year is only a tiny fraction of the capital stock figures[5]. In terms of the measurement of the capital stock, the perpetual inventory method is used which makes an initial assumption regarding the size of the capital / output ratio.

- **LABOUR[6]** : The definition of the maximum potential output contribution of labour input is more involved since it is more difficult to assess the "normal" degree of utilisation of this factor of production. Labour input is defined in terms of hours. Determining the trend of labour input involves several steps. In defining the trend input we start from the maximum possible level, namely the actual population of working age[7]. We obtain the trend labour force by mechanically detrending (using an HP filter) the participation rate. In a next step we calculate trend un/employment to be consistent with stable, non accelerating, (wage) inflation (NAWRU). Finally, we obtain trend hours worked (potential labour supply) by multiplying trend employment with the trend of average hours worked. One of the big advantages of this approach is that it generates a potential employment series which is relatively stable whilst at the same time also providing for year-to-year changes to the series to be closely linked to long run demographic and labour market developments in areas such as the actual working age population, trend participation rates and structural unemployment.

[5] An exception to this "rule" has been the recent financial crisis where the large fall in investment rates led to deep declines in the contribution of capital to potential output growth.

[6] Since Eurostat and the OECD have agreed that the national accounts (as opposed to the labour force survey) is the preferred source for labour input data, the production function approach now uses the national accounts for the labour input variables i.e. for hours worked and employment.

[7] The OGWG has extensively discussed the possibility of replacing the actual population of working age (POPW) series in the production function method with a smoothed series. These discussions were initiated by a number of complaints from specific Member States that POPW changes (driven essentially by migration flows) were generating erratic and often counterintuitive shifts in their potential growth rates. Following a number of notes from the Commission services on this issue and discussions in the working group, it is now clear that it would be inappropriate to smooth the overall POPW series since the migration component of POPW (rather than births and deaths i.e. the natural increase component) is the only part of the series which has both cyclical & structural elements and consequently smoothing the total series would risk removing a substantial amount of valuable information. The OGWG agreed that the only viable solution would be to just smooth the migration component but this will be difficult since official EU-wide migration statistics are very poor, with a particular problem with respect to the migration statistics for the working age cohorts. In a follow-up discussion in the OGWG on this issue, Eurostat gave a short presentation on the present state of, and the future prospects for, EU migration statistics. Unfortunately, despite having agreed a new regulation in 2007 for collecting comparable migration data in the EU member states, it is clear that Eurostat is not yet in a position to provide the Commission services with the type of data needed to split the POPW series in the manner suggested. To do so in the future, Eurostat will have to provide long series of emigration and immigration data, as well as regular updates and projections. Until Eurostat are in a position to provide the necessary migration data, it will not be possible to introduce such a change in the method i.e. a split of the POPW series into a smoothed "net migration" component combined with the actual "natural increase" component.

- **<u>TREND EFFICIENCY</u>** : Within the production function framework, potential output refers to the level of output which can be produced with a "normal" level of efficiency of factor inputs, with this trend efficiency level being measured using a bivariate Kalman filter model which exploits the link between the TFP cycle and the degree of capacity utilisation in the economy.

Normalising the full utilisation of factor inputs as one, potential output can be represented as follows :

(3) $$Y^P = (L^P E_L^T)^\alpha (K E_K^T)^{1-\alpha}.$$

1.2 Medium-Term Extension

While the production function derived potential output estimates provide a good picture of the present output capacity of economies, they should not however be seen as forecasts of medium-term sustainable rates of growth but more as an indication of likely developments if past trends were to persist in the future. If, for example, a country's potential growth rate is 2% in 2010, it can only be sustained at that rate in future years if none of the underlying driving forces change. Any longer term assessment would need therefore to be based on a careful evaluation of the likelihood that present rates of growth for labour potential, productive capacity and TFP will persist over the time horizon to be analysed. In this context, the tables and graphs shown in annex 6 provide results for a 3 year, medium-term, extension (covering the period 2012-2014) of the Commission services Spring 2010 short term forecasts up to 2011. It is important to stress that this technical extension is in no way a forecast for these years - it is simply an attempt to illustrate what would happen if the trends of recent years were to persist into the medium term. In more specific terms, on the basis of a number of explicit assumptions, including transparent ARIMA procedures, the potential growth rates for the medium term are calculated using the following key inputs :

- **<u>1. TREND TOTAL FACTOR PRODUCTIVITY (TFP) :</u>** The TFP trend is estimated from the Solow residual by using a bivariate Kalman filter method that exploits the link between the TFP cycle and capacity utilization. The Solow residual employed in the estimation process is calculated until the end of the short term forecast horizon using forecasts for GDP, labour input and the capital stock, which permits the extension of the TFP series by two additional observations. Since there are no forecasts of the degree of capacity utilization in the economy, this means that the Kalman filter model is estimated with two missing values. During the estimation process, these missing values for capacity utlization are, however, not problematic since the operation of the Kalman filter is not dependent on the availability of a forecast extension. The filter can in fact compute linear projections through a recursive procedure which yields the expected value of the TFP cycle on the basis of only the available observations. The Kalman filter in turn produces trend TFP forecasts by simply running the Kalman filter out of sample, over the required medium-term forecast horizon.

- **<u>2. NAWRU'S :</u>** The trend specification chosen for the NAWRU implies that the best prediction for the change in the NAWRU in future periods is the current estimate of the intercept. This basically implies that the slope of the NAWRU in the last year of the short-term forecasts should be used for the medium-term projection. Such a specification seems problematic for longer-term projections since it will eventually violate economic constraints (such as non-negativity of the NAWRU, for example, or balancing forces in the economy). An alternative specification which is more consistent with the common notion of the NAWRU as a stable long run level of the unemployment rate would be a random walk without drift. This specification would imply a flat extrapolation of the last NAWRU value. Although this specification does not work well in estimation for European data where persistent trend changes of the unemployment rate can be observed, it may be a more plausible specification for the projections. The projections in practice constitute a compromise between these two concepts, with the medium-term NAWRU estimated according to the following rule:

$$NAWRU_{t+1} = NAWRU_t + .5 * (NAWRU_t - NAWRU_{t-1})$$

In forecasting the NAWRU, 50% of the most recent decline / increase is allowed for. This implies that the NAWRU is practically stable in the last year of the medium term extension because, after 3 years, the change in the NAWRU only amounts to 12.5% of the change in the last year of the short-term forecasts.

- **3. POPULATION OF WORKING AGE :** In terms of a projection for the population of working age for the medium-term (i.e. the three years following ECFIN's short-term forecast horizon), since Eurostat periodically produce long range population projections for all of the EU's Member States, it was decided that the most recent vintage of the Eurostat projections should be used. At present, ECFIN uses the Eurostat EUROPOP 2008 set of population projections.

- **4. PARTICIPATION RATE CHANGES :** On the basis of the forecasts by ECFIN's desk officers for the labour force and the population of working age for the individual countries, the implied total participation rate up to the end of the short-term forecasting period is produced and this latter series is extended on the basis of simple autoregressive projections with an estimated time trend. A further 3 years are added at the end of the series to limit the end point bias problem. The HP trend is then calculated on the whole series[8].

- **5. AVERAGE HOURS WORKED :** Labour input in the method is decomposed into the number of employees and the average hours worked per employee. The hours worked series is extended using an ARIMA process[9]. As for other components, the series is

[8] Over recent forecasting exercises, for calculating trend labour force participation rates and trend hours worked, a lambda of 10 instead of 100 has been used in the HP filter. In terms of an explanation for this change, with respect to participation rates, an analysis of recent developments in actual participation rates suggest a flattening out in trend participation rates rather than further increases and consequently the smoothing parameter has been adjusted to better reflect this emerging new situation. Use of a lambda of 100 would have given rise to an excessively optimistic medium term trend for participation rates. With regard to hours worked, the situation is the opposite to that for participation rates, with the long run pattern of falls in the number of hours worked per worker changing recently towards a less negative contribution. Again a lambda of 10 allows one to better reflect this more recent change in actual hours worked in the trend series. The hours worked and participation rate series are of course interlinked, with much of the increase in participation rates over recent years due to an inflow of part-time workers into the workforce, with negative knock-on effects in terms of hours worked per worker. This pattern, as mentioned earlier, now appears to be changing towards a less positive trend for participation rates which, in turn, is accompanied by a less negative hours worked trend.The combined effect of these changes is however relatively small since they tend to offset each other.

[9] For the time period in the aftermath of the crisis, the ARIMA extension was not used. Instead the "pre-crisis" trend value was imposed on the medium term, thereby fully attributing the decline in hours worked to the crisis (i.e. the decline in hours worked was cyclical not structural in nature).

extended by 6 years, to avoid the end-point bias, and then smoothed. Only the first 3 years are then used for the medium-term extension.

- **6. Investment to (potential) GDP ratio :** Since the purpose of the exercise is to get an estimate for potential output in the medium-term, the investment to potential GDP series is used as an exogenous variable, while investment itself is made endogenous. Generally, an AR process, allowing for a constant and a time trend, is specified and estimated using the full range of data, including ECFIN's short-term forecasts. For a constant investment to GDP ratio, investment responds to potential output with an elasticity equal to one.

Technical Specification of the Model Used

The model used can be summarised as follows:

Exogenous Variables

- *POPW - (Population of Working Age)*
- *PARTS - (Smoothed Participation Rate)*
- *NAWRU - (Structural Unemployment)*
- *IYPOT - (Investment to Potential GDP Ratio)*
- *SRK - (Kalman Filtered Solow Residual)*
- *HOURST – (Trend, average hours worked)*

Endogenous Variables

- *LP - (Potential Employment)*
- *I - (Investment)*
- *K - (Capital Stock)*
- *YPOT -(Potential Output)*

1. Potential Labour input

$$LP = (POPW * PARTS * (1 - NAWRU)) * HOURST$$

2. Investment and Capital

$$I = IYPOT * YPOT$$

$$K = I + (1 - dep)K(-1)$$ [10]

3. Potential Output

$$YPOT = LP^{.65} K^{.35} SRK$$

4. Output Gap

$$YGAP = (Y / YPOT - 1)$$

[10] The depreciation rate is assumed to remain constant over the projection period.

Box 1 : Using the production function (PF) approach to quantify the impact of the financial crisis on potential output

The PF methodology can be used to assess the repercussions on potential output of the present financial crisis over a short to medium term time horizon. Understanding the channels through which the crisis will influence potential and obtaining reliable broad orders of magnitude for the overall effect is currently a critical challenge for policy makers. Such work is vital in drawing up effective "exit strategies" & in formulating supply side policies aimed at minimising any crisis-related output losses over the medium to long term. The PF approach can be useful in this respect since it provides a framework for quantifying the impact of the crisis on the different components of potential output, namely labour, capital and total factor productivity (TFP). A review of the literature on past financial crises, including the experiences of countries such as Finland, Sweden & Japan in the early 1990's, points to the following factors as important influences on the evolution of the different components of growth in the post-crisis period :

- ***Labour** : A lot of the research work in this area suggests that the length of the downturn in the aftermath of the crisis is pivotal in determining the extent of any damage to an economy's underlying labour potential. For example, a short recession would not be expected to negatively affect the pace of growth of an economy's labour force, thereby leaving this component of potential output broadly unharmed in the longer run. However, a long and deep recession may cut the potential labour force by discouraging some workers from seeking a job and by reducing migration flows. Moreover, the potential labour supply could be damaged if the crisis heightens the political pressure to delay reversing a number of short term, crisis-related, measures in the recovery phase (e.g. a temporary increase in unemployment benefits) or to implement policies to curb the growth in labour market participation rates (e.g. early retirement schemes). Finally, in the case of a prolonged recession, long unemployment spells may cause a permanent destruction in human capital, leading to an irreversible rise in the NAWRU -due to so-called "hysteresis effects"- and further losses in the potential output level. By contrast, the NAWRU is not likely to affect the long-term pace of potential growth, since this would implausibly require that it permanently increases over time.*

- ***Capital** : A crisis can also reduce potential output in the short and medium term through its adverse impact on investment. The downward pressure on investment results firstly from increases in risk premia on loans to firms & households due to shifts in attitudes towards risk; secondly, from the more cautious lending behaviour of banks resulting from, amongst other things, credit constraints; and thirdly, from a correction to more 'normal" investment levels following the over-investment pattern of the "boom" period (generated, on this occasion, by bubbles in both the financial & housing markets). Given the unprecedented financial market problems, it is expected that not only will the price and volume of capital be affected but there is also a distinct risk that an impaired capital allocation system may result not only in a more anaemic investment trend in the recovery phase but also in a less than optimal reallocation of capital resources to aid the crucial restructuring process.*

- ***TFP** : Theory does not give a clear answer as to what the expected impact of the crisis on long-run TFP might be. Besides a number of mechanisms that tend to dampen TFP in the aftermath of a crisis, there are also arguments that downturns can have a positive TFP impact as they can induce a process of essential restructuring and cleansing in the economy. Consequently, ex ante, the expected effect of the crisis on TFP is ambiguous, with a range of specific factors making any definitive assessment of the fallout from the current crisis particularly uncertain. These factors include the need to allow for the expected "one-off" downward shifts in the level of TFP associated with industrial restructuring, with some industries (e.g financial services and construction) likely to experience permanent reductions in the level of their activities as a result of the crisis; the difficulty in estimating realistic capital obsolescence rates; the uncertainties regarding the financial crisis impact on R&D spending and on the financing of R&D; the extent to which the crisis results in scarce resources being locked into relatively unproductive activities; and finally the possibility of a crisis-induced shift away from the relatively-high-TFP growth manufacturing sector towards services.*

The PF methodology can be used to provide a quantification, over a short to medium term time horizon, of at least some of the above transmission channels, with table 1 & graph 1 providing an illustration of the type of results to be expected. For this exercise, an EU aggregate has been calculated for those 15 EU Member States where the bivariate Kalman filter approach can be used in the estimation of both the NAWRU and TFP. This EU15 aggregate is based on the Commission services Spring 2010 short-term forecasts up until 2011, as well as the medium term extension up to 2014 using the agreed extrapolation method. According to the method, the severe economic crisis has led to a sharp downward revision in EU15 potential growth rates over the short run, with EU15 rates being roughly cut in half in 2010 / 2011 compared with 2006 / 2007, i.e. from a growth rate of 1.9% to 1%. This weaker short-term potential growth rate performance, combined with a relatively sluggish recovery over the medium term (with rates still lower in 2014 compared with the pre-crisis period), is expected to give rise to a cumulated output loss of around 3 ½ % in the EU15 by 2014 when compared with a pre-crisis growth path which has been calculated on the basis of the average potential growth rate for the period 2000-2007 (note – this estimated 3 ½ % loss in the level of potential output excludes crisis-unrelated demographic effects).

In terms of the components of growth, table 1 and graph 1 show that the PF results are broadly in keeping with the expected effects for labour, capital & TFP laid out earlier in the box :

- *Regarding labour, the method predicts that the crisis will produce substantial, short-run, reductions in the growth contribution of labour (driven, in part, by increases in structural unemployment) but, based on the Spring 2010 forecast of a recovery in actual GDP growth from 2011 onwards, the contribution of labour will relatively quickly revert to pre-crisis levels over the medium term. In other words, the initial negative impact of the crisis on EU labour markets is likely to prove largely transitory in nature.*

- *With respect to capital, in keeping with the conclusions of the literature & the experiences of countries such as Finland, Sweden & Japan, the method predicts that the contribution of capital to growth will be reduced substantially over the short run. However, unlike labour, the pace of any recovery in investment over the medium term is likely to be quite subdued, with this sluggishness in investment patterns ensuring that the contribution of capital to growth in 2014 will still be lower than in the pre-crisis period.*

- *For TFP, the PF results support the a priori assumption that the final outcome is dependent on a range of offsetting positive and negative factors. This balancing act appears to produce a slightly negative overall impact as far as the short run is concerned (with one-off downward level shifts in a few crisis-related industries being a possible explanation) but with these losses being quickly recouped over the medium term (perhaps as the gains from earlier restructuring efforts start to emerge). However, caution is clearly needed with respect to predicting the future evolution of TFP given the wide range of factors at play & the fact that any scenario is dependent upon the forecasts for overall economic activity being realised.*

In overall terms, the PF results for the period of the crisis and its aftermath look to be broadly consistent with the mainstream predictions for such "shocks" emanating from the literature & from an analysis of a number of relevant individual country experiences. The PF method would suggest that the crisis will result in a sharp, short-run, downturn in potential growth rates, followed by a slow medium term recovery. In addition, although the growth rate effects of the crisis are likely to be transitory, not permanent, in nature, nevertheless the initial sharp fall in growth rates combined with a relatively slow return to pre-crisis rates over subsequent years, is expected to produce a substantial loss in the EU15's level of potential output. This shortfall in levels could reach 3 ½ % by 2014, with such losses having significant implications in terms of the living standards and fiscal capacity of the most affected EU15 economies.

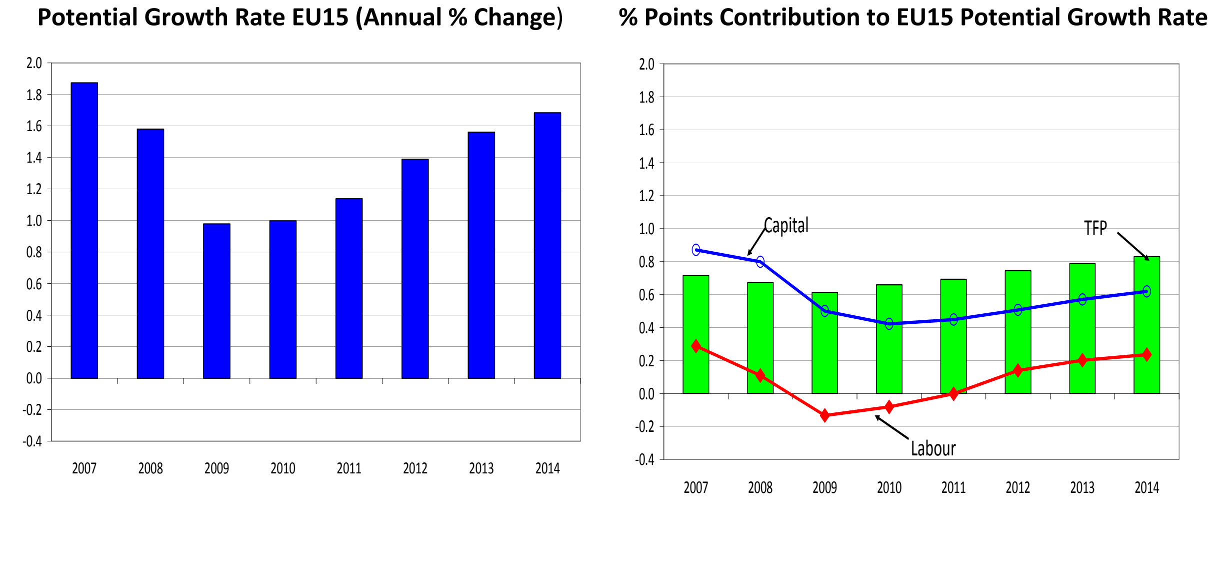
Table 1 : Potential Growth Rate Developments in the EU15 (2000-2014)

	Potential Growth (excluding demographic effects)	% Points Contribution to Potential Growth			NAWRU	Investment Ratio
	(Annual % change)	Labour (excluding demographic effects)	Capital	TFP (bivariate KF model)	(% of Labour Force)	(% of potential output)
EU-15						
(2000-2007)	**(1.8)**	**(0.1)**	**(0.8)**	**(0.9)**	**(7.8)**	**(20.6)**
2008	1.3	-0.2	0.8	0.7	7.9	21.2
2009	0.8	-0.3	0.5	0.6	8.3	18.6
2010	0.9	-0.2	0.4	0.7	8.5	18.0
2011	1.1	0.0	0.4	0.7	8.7	18.2
2012	1.4	0.2	0.5	0.7	8.8	18.7
2013	1.6	0.3	0.6	0.8	8.9	19.2
2014	1.8	0.3	0.6	0.8	8.9	19.6
Cumulated loss in levels*	**-3.4**	**-0.7**	**-1.5**	**-1.3**		

**Cumulated loss in potential output level in 2014 compared with a pre-crisis growth path (2000-2007)*

Source: Commission services

Graph 1 : EU15 potential growth rates & their labour, capital & TFP components (2007-2014)



Source: Commission services

SECTION 2 : NEW METHODOLOGY FOR CALCULATING TOTAL FACTOR PRODUCTIVITY (TFP)

2.1 : TFP TREND-CYCLE DECOMPOSITION : PROBLEMS WITH EXISTING HP FILTER METHOD & OVERVIEW OF NEW KALMAN FILTER APPROACH

As mentioned earlier, following the decision of the Economic Policy Committee in December 2009, DG ECFIN will replace the previously used Hodrick-Prescott (HP) method for detrending TFP with a new Kalman filter based approach which exploits the link between TFP and capacity utilization. This step has been taken to address a number of problems with the HP filter method, especially its tendency to produce imprecise estimates at the end of the sample period, most notably close to turning points. The new KF method is expected to address some of the shortcomings with the existing approach. In particular, it should lead to more precise trend TFP estimates which are less frequently revised over time.

Problems with existing HP method : The HP filter methodology suffers from a number of well-documented inadequacies, including :

- Firstly, whilst the HP filter is a univariate technique that can be applied in a relatively mechanical way to series with very different characteristics, this versatility comes at a cost. Unfortunately, the technique ignores the structure of the underlying economic system and does not generally allow for exploiting additional relevant information apart from that already included in the series of interest (see Kuttner – 1994[11]).

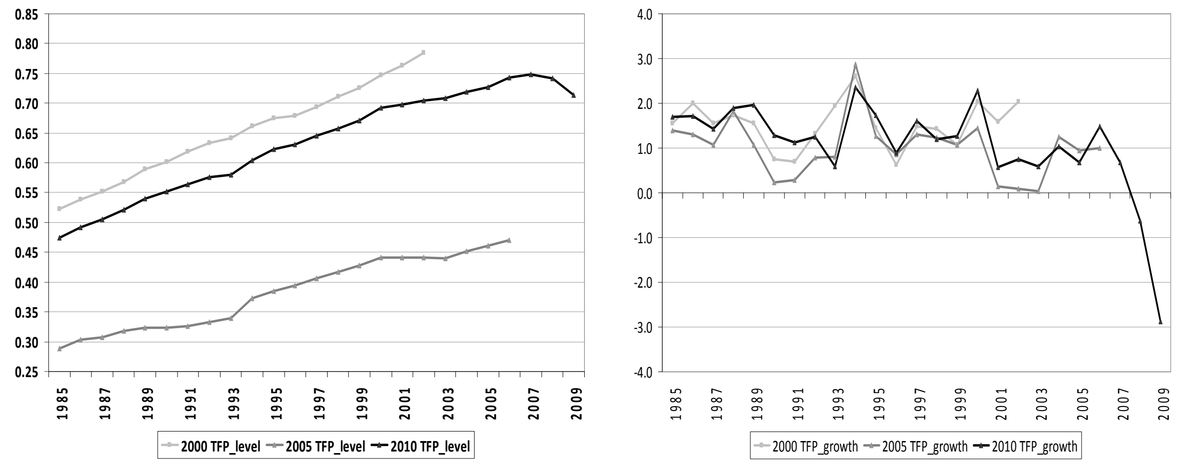
- Secondly, in order to carry out a trend-cycle decomposition of a series at a given date, the HP filter requires information about the behaviour of the series at earlier as well as at future dates. This poses difficulties at the end of the sample, where by definition only the observations from the earlier dates are available, with the result that use of the HP filter often leads to the so called end-point bias problem (see Baxter and King - 1995).

- Finally, another difficulty with using the HP filter for TFP detrending is that TFP series are themselves estimated, and as such undergo frequent revisions. This in turn can lead to substantial revisions in the trend-cycle decomposition. To see the scale of the problem, graph 2.1 displays the TFP "vintages" for the EU15 aggregate. Each curve represents a specific TFP vintage i.e. a time series of TFP level estimates for the period 1985 to 2009 obtained with data available in one particular year. Three TFP vintages are presented for the EU15 aggregate (for every fifth year starting in 2000 and ending in 2010). As can be seen, there has been substantial uncertainty about the level, and sometimes the growth rate, of TFP for the EU15 as a whole over the period 2000-2009.

This uncertainty surrounding TFP vintages is a clear source of instability in the TFP trend-cycle decomposition. Together with the HP filter's end point bias problem, it can lead to substantial revisions in the TFP trend and cycle estimates over time.

[11] In his influential paper on output gap estimation, Kuttner (1994) spoke about "the lack of any substantive economic content" in the measures generated with univariate methods such as the HP filter.

Graph 2.1 : TFP 1985-2009 : EU15 (2000, 2005 & 2010 vintages)



Footnote: TFP level = index in log levels normalized to zero in 1965

Source: Commission services

New Kalman Filter approach addresses some of the concerns with the existing method : With the objective of producing more reliable real time trend TFP estimates, with knock-on benefits with respect to output gap revisions, a new Kalman Filter (KF) based approach will be formally introduced in the method in the Autumn 2010 forecasting exercise.

This new KF approach can be shown to ensure that trend TFP estimates are less frequently & less sizeably revised over time. This reduction in uncertainty surrounding TFP vintages can be achieved by applying a bivariate method which exploits the relationship between TFP and another observable economic indicator that would carry information which cannot be extracted in real time from the TFP series alone. For such an indicator to be useful, however, it must possess two important characteristics :

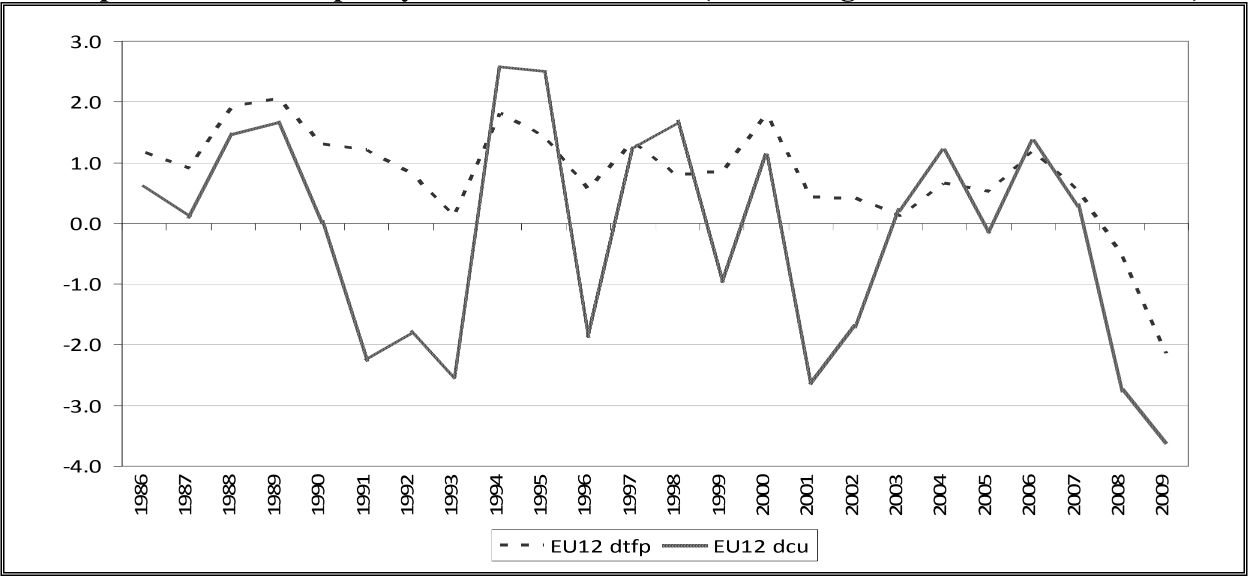
- Firstly, it should be measured with acceptable precision and without revisions. This would be helpful in reducing TFP trend estimate revisions due to periodic updates of the underlying series.[12]

- Secondly, the indicator should strongly co-move with the unobserved cyclical component of TFP, hence enabling unbiased extraction of the TFP cycle even at the end of the sample.

A good candidate for such an indicator is capacity utilization. Graph 2.2 displays the TFP (autumn 2009 vintage) and capacity utilization composite indicator series for the EU15. An inspection of the graph confirms that the two series are strongly correlated for EU15. A formal quantitative measure of the strength of the link between the two series, which confirms the visual evidence presented in graph 2.2, is given in section 2.2. Before presenting this evidence, however, it is helpful to provide a short description of the KF approach itself.

[12] It should be understood however that such revisions will never be completely eliminated.

Graph 2.2 : EU15 Capacity utilization and TFP (both in log differences and rescaled)



Source: Commission services

KF Approach - A joint model for TFP and capacity utilization : The new bivariate KF method exploits the link between the TFP cycle and capacity utilization that arises in the Cobb-Douglas framework. Its basic structure is similar to the Phillips-curve augmented unobserved component model proposed by Kuttner (1994) for estimating potential output and output gaps in the US.

As explained earlier in Section 1, TFP is related to the labour efficiency (E_L) and capital efficiency (E_K) levels of the available technology and to labour and capital capacity utilization (U_L and U_K respectively) according to:

(2.1) $$TFP = (E_L^{\alpha} E_K^{1-\alpha})\,(U_L^{\alpha} U_K^{1-\alpha})$$

where constant α represents the labour share of income. Since efficiency is a persistent process whereas capacity utilization depends on current economic conditions, equation (2.1) suggests a TFP-decomposition into a trend P and a cycle C such that TFP = P × C with:

$$P = E_L^{\alpha} E_K^{1-\alpha} \qquad C = U_L^{\alpha} U_K^{1-\alpha}$$

The first relationship has no empirical relevance since efficiency is not measured. Capacity utilization measures are instead available, although so far without discriminating between the different production factors. Only aggregate capacity utilization series, for example series *U*, can be readily obtained. By construction, we expect *U* and U_K to be significantly correlated. Given that the average hours worked per employee series already contains some cyclical movements, the link with labour utilization should be somewhat looser. However, if there are fluctuations in the degree of labour hoarding that are not captured by the hours worked series, a correlation between labour and capital utilization may nevertheless be present. It is thus assumed:

$$u_L = \gamma u_K + \varepsilon \qquad 0 < \gamma < 1$$

where lowercase letters denote logarithms and ε is a random shock, with its properties defined in annex 1. Hence log-TFP is related to capacity utilization through :

$$tfp = p + (1 - \alpha + \alpha\gamma)\, u + \alpha\, \varepsilon$$

This link is exploited to detrend TFP through the following bivariate model :

$$\text{(2.2)} \qquad \begin{aligned} tfp_t &= p_t + c_t \\ u_t &= \mu_U + \beta\, c_t + e_{Ut} \qquad \beta = \frac{1}{1 - \alpha(1-\gamma)} > 1 \end{aligned}$$

where the small-case letters indicate log-levels of their large-case letter counterparts. Given that both α and γ lie in the (0,1)-interval, the loading coefficient β should be greater than one. The value of β can be considered a formal quantitative measure of the link between capacity utilization and TFP. e_{Ut} in the second equation of system (2.2) stands for a random shock, see annex 1. System (2.2) must be completed with assumptions about the unobserved components dynamics. Their general structure as well as the specific assumptions made for each of the Member States are given in annex 1.

Construction of the capacity utilization composite indicator : Capacity utilization in the EU is measured using two indicators: the Capacity Utilization Indicator (CUI), which is available for manufacturing only, and the Business Survey Capacity Indicator (BS) collected for both manufacturing and services as part of the European Commission's Business and Consumer Survey Programme (see the European Economy Special Report 5/2006 for details). Due to its wider scope, the BS is thought to be a superior measure of capacity utilization for the economy as a whole. It has the disadvantage however that its services part has only been collected since the years 1995-1998 for most of the Member States. For this reason, the CUI, suitably rescaled, is used for the period when the BS is not available, whilst the BS is used for the remaining years[13].

Model estimation : The model can be estimated using the standard maximum likelihood method or by applying a Bayesian approach. The latter is preferred as it overcomes a stability problem that can occur with maximum likelihood estimation whereby 0-coefficient estimates are obtained for structural shock variances. Another advantage of the Bayesian approach is that any additional information, possessed by modellers and policy makers, which is not captured in the data can however be easily incorporated into the analysis. For instance, some information is *a priori* available about the periodicity of the TFP cycle or the inertia of its trend.

In the Bayesian framework, all parameters are considered as random variables with an initial distribution that reflects prior knowledge. The estimation procedure aims at delivering posterior distributions of all unobserved quantities given both prior assumptions and observations. The likelihood is evaluated by the bivariate model (2.2) into a state space format so that the Kalman filter can be applied.

[13] Only the CUI is used for Luxembourg since business surveys are not conducted for this country. Ireland has interrupted its business surveys in 2009.

The framework allows for some flexibility in modelling choices. In particular, trend TFP can be modelled as an integrated series of order 1 or 2 (i.e. either I(1) or I(2) respectively). The choice of the order of integration is then data-driven and is done separately for each Member State.[14] Other details about the methodology and the prior distributions are given in annex 1. All computations are made by the programme GAP which has been developed in the Commission's Joint Research Centre and is downloadable from the "Output Gaps" internet website, together with a user-manual.

2.2 : REAL-TIME PERFORMANCE OF THE NEW TFP METHODOLOGY

Model validation : As mentioned in the previous sub-section, the β-coefficient in equation (2.2) measures the strength of the relationship between capacity utilization and the TFP cycle. Table 2.1 reports the posterior mean and 90%-confidence intervals obtained with the 2009 TFP vintage for 15 EU countries.[15] As can be seen, for all countries the 90%-confidence interval excludes 0: hence the TFP-CU common cycle hypothesis is not refuted by the data. Model (2.2) also foresees that β should be greater than 1. With a posterior mean at 0.64, Greece is the only country for which this prediction is refuted. For two further countries, the Netherlands and Portugal, whilst the value of β obtained is below 1, it is nevertheless greater than 0.9 in both cases. For the other 12 countries β is greater than 1, as expected. These results confirm the earlier visual observation, using graph 2.2, that there is a strong statistical link between capacity utilization and the TFP cycle.

Table 2.1 : Posterior mean and 90%-confidence band for β-coefficient

Country	Posterior mean	90%-interval
Austria	1.217	[0.841,1.606]
Belgium	1.265	[0.706, 1.856]
Denmark	1.175	[0.836, 1.629]
Germany	1.362	[0.602, 2.029]
Greece	0.636	[0.148, 1.140]
Spain	2.340	[1.557, 3.167]
Finland	1.630	[1.034,2.212]
France	1.792	[1.189, 2.510]
Ireland	1.107	[0.549, 1.662]
Italy	1.629	[1.301, 2.053]
Luxembourg	1.275	[0.793, 1.800]
Netherlands	0.934	[0.610, 1.228]
Portugal	0.945	[0.200 1.623]
Sweden	1.549	[0.931,2.239]
UK	1.116	[0.700, 1.565]

(**Notes**: The 90%-confidence interval is the smallest region of the β-posterior distribution that contains 90% of the distribution. The results in the table are obtained with the TFP autumn 2009 vintage).
Source: Commission services

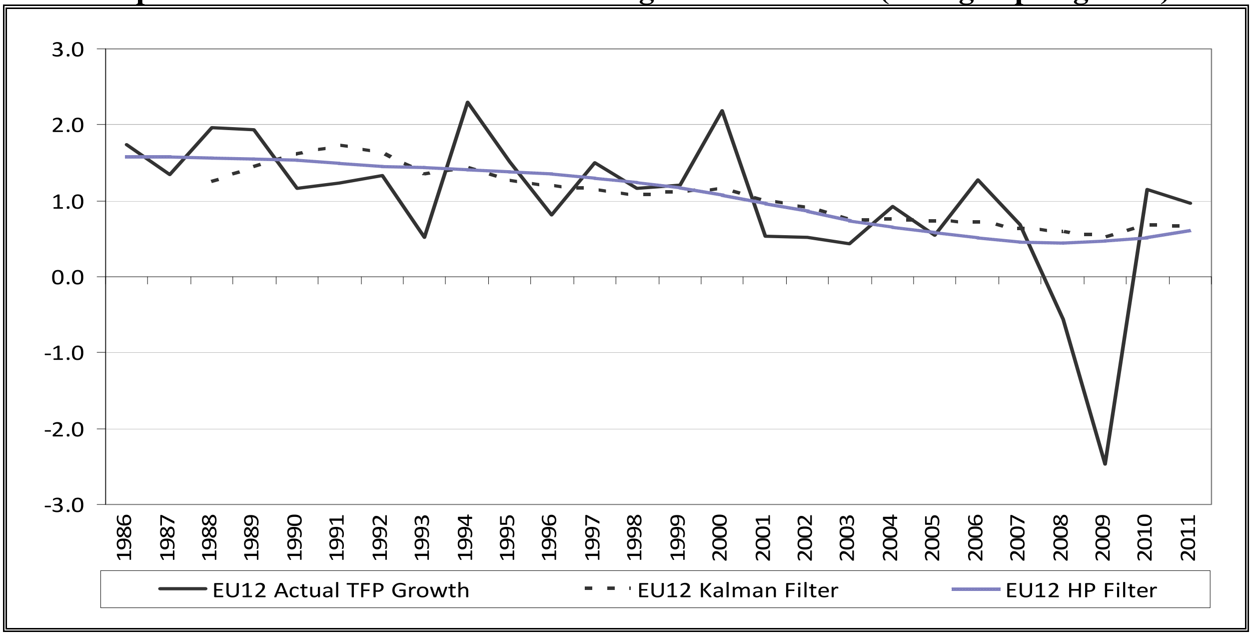
[14] At this moment in time the I(1) assumption is preferred for all Member States. In principle the HP filter-based method can also be used under the I(1) or I(2) assumption, but the process of identification of the correct degree of integration is less formal, and hence also less appealing.

[15] These countries are Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, the United Kingdom, Austria, Finland and Sweden. The details on the model used for each country are given in Annex 1.

Comparison of results between the "old" and "new" TFP methods : The real-time trial estimation performed on the autumn 2009 TFP vintage confirmed that the new method is likely to produce more realistic TFP trend-cycle decompositions than its univariate predecessor. As expected, one clear problem with the univariate estimates turned out to be their excessive sensitivity to the last few observations in the sample.

As an illustration of the differences in the results obtained with the two methods, one should consider the aggregate EU15 TFP growth rate, as shown in graph 2.3.[16] This graph shows that as a result of the global financial crisis, the EU's TFP growth rate in the years 2008-2009 fell to unprecedentedly low levels. This significant drop in the values of the last sample observations weighed heavily on the HP filter-based TFP trend estimates, which turned out to be strongly U-shaped between the years 2008-2012, with the lowest point around 2009.[17] In contrast, the trend growth estimate obtained with the bivariate method is much smoother. Indeed, the bivariate estimate does not display as sharp a fall, as its HP-based counterpart, over the years 2008-2009 and is considerably more optimistic over this period. On the other hand, the HP method predicts a strong rebound of the TFP growth rate after 2009, which is not the case for the newly introduced method. These results confirm the greater economic realism of the new TFP method. For example, whilst the economic crisis could have somewhat reduced trend TFP growth, the extent of the reduction suggested by the HP filter-based decomposition is not very plausible. Similarly, given the fragility of the European economy after the crisis, & based on the evidence from the literature on financial crises and from individual country experiences, it is widely regarded as being excessively optimistic to expect a strong rebound in EU trend TFP growth over a medium-term time horizon.

Graph 2.3 : EU15 – Actual & trend TFP growth estimates (vintage Spring 2010)



Note: The observations for years 2010-2012 are forecasts.
Source: Commission services

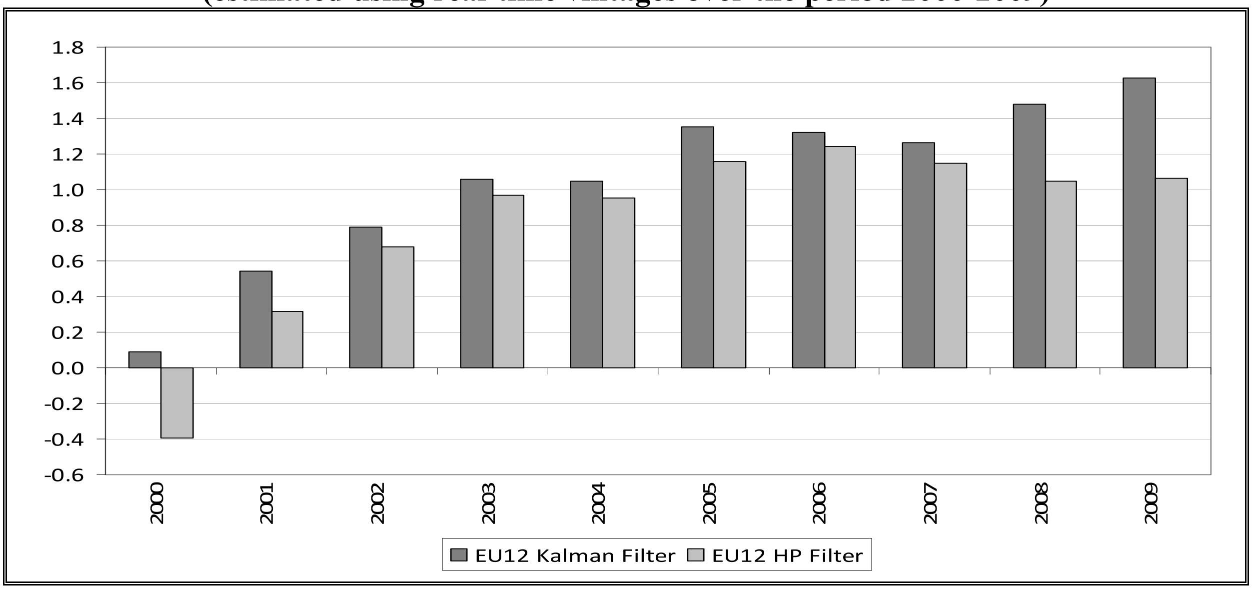
[16] On this and the following graphs, the EU15 aggregate which is used only includes countries for which the capacity utilization measure extends back to at least 1987. This excludes Austria, Finland and Sweden from the list of countries.

[17] The observations for the years 2010-2012 are forecasts that are included to better illustrate the differences between the two alternative estimates.

KF approach brings gains in terms of "revisions" : As was documented earlier, at the end of the sample the HP filter has a tendency to attribute part of the cycle to the TFP trend. This tendency is a consequence of its excessive sensitivity to the last observations in the sample. The bivariate method is partly immune to the end-point bias problem, as it can extract the information about the cycle from an additional, explicitly observable indicator- capacity utilization - that is strongly tied with the cycle variable. The resulting differences in estimates can be especially striking at turning points i.e. at exactly those periods when precision is most crucial for policy makers.

Graph 2.4 shows the path taken by the EU15 cycle estimates for the individual year 2000, i.e. the year when TFP peaked due to the dot-com bubble. These estimates were obtained based on consecutive real-time TFP vintages from 2000 to 2009. In 2000, the HP and KF methods produce cycle estimates with exactly the opposite signs. Graph 2.4 shows that as new observations become available in consecutive TFP vintages, the HP estimates are revised upwards in the direction of the bivariate ones and their sign changes from negative to positive. This confirms the higher precision, in relative terms, for the earlier estimates obtained with the bivariate method[18]. These differences between the 2 methods can be traced to the fact that the 2000 peak in the TFP data led the HP filter to overshoot the trend growth for the earlier TFP vintages, which resulted in the estimated cycle becoming negative. The bivariate estimate does not suffer from this drawback due to its use of the capacity utilization series. The capacity utilization series contained the information about the unusually high level of economic activity in 2000 from the outset, which allowed the KF approach to correctly attribute the high level of TFP in 2000 to cyclical effects, and not to a shift in the underlying trend.

Graph 2.4 : HP & Kalman Filter Estimates of the EU15 TFP cycle for the year 2000 (estimated using real-time vintages over the period 2000-2009)



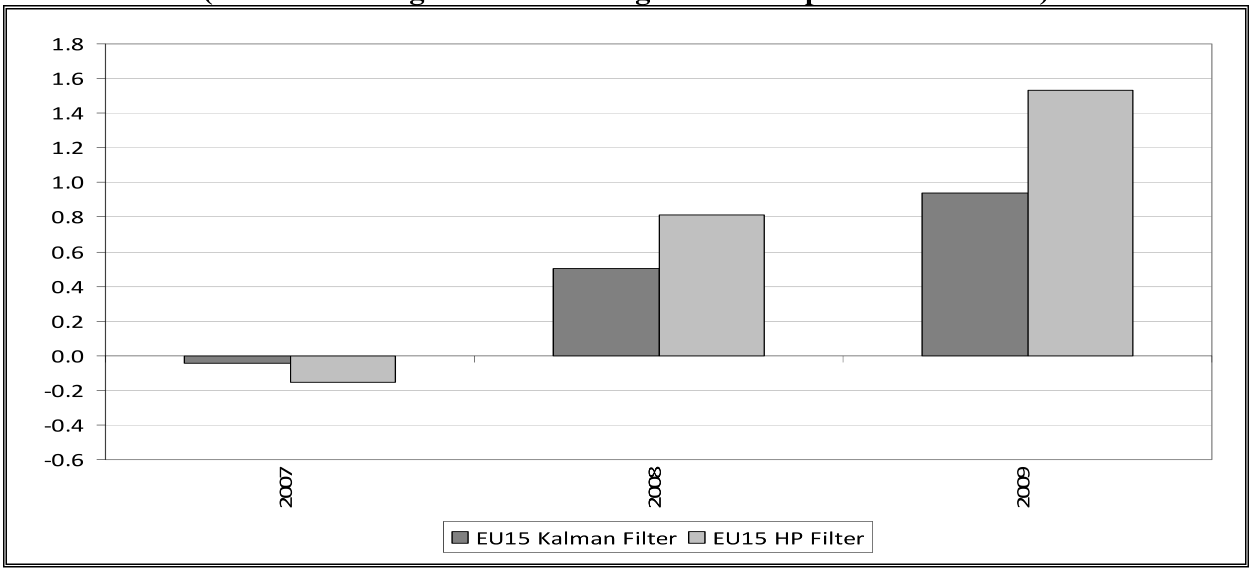
Source: Commission services

[18] This gain in precision is clearly only in relative terms since in absolute terms the level of uncertainty surrounding TFP estimates remains high, as evidenced by the extent of the revisions over time for both the HP & KF estimates of TFP for the individual year 2000.

Graph 2.5 illustrates a similar point for a more recent period. It shows the path followed by the cycle estimates for the year 2007, as obtained using consecutive vintages from 2007 to 2009. The year 2007 was a turning point in the EU economy. The TFP series peaked in this year and fell rapidly in the years 2008-2009. As can be seen, compared to the HP method, the use of the capacity utilization series in the KF approach reduces the revisions to the 2007 estimates, on the basis of the 2008 and 2009 vintages. The above average level of capacity utilization in the year 2007 allowed the KF to estimate a relatively low trend TFP already in real time, despite a high value of TFP for the year in question. On the contrary, the HP method, driven by the very optimistic TFP level in 2007, overestimated the 2007 trend in real time. This overestimation subsequently resulted in large revisions when the actual information about the downturn in 2008-2009 became visible in the TFP series. In a similar manner, the divergences in the estimates of the 2000 cycle that took place starting with the 2008 vintage (shown earlier in graph 2.4) is also likely to be a consequence of the 2008-2009 downturn in the EU's economy.

The above examples of the 2000 and 2007 TFP cycle estimates indicate firstly that the HP filter estimates are prone to large revisions due to the arrival of new data vintages and secondly that this can be a feature even for distant periods in the past.

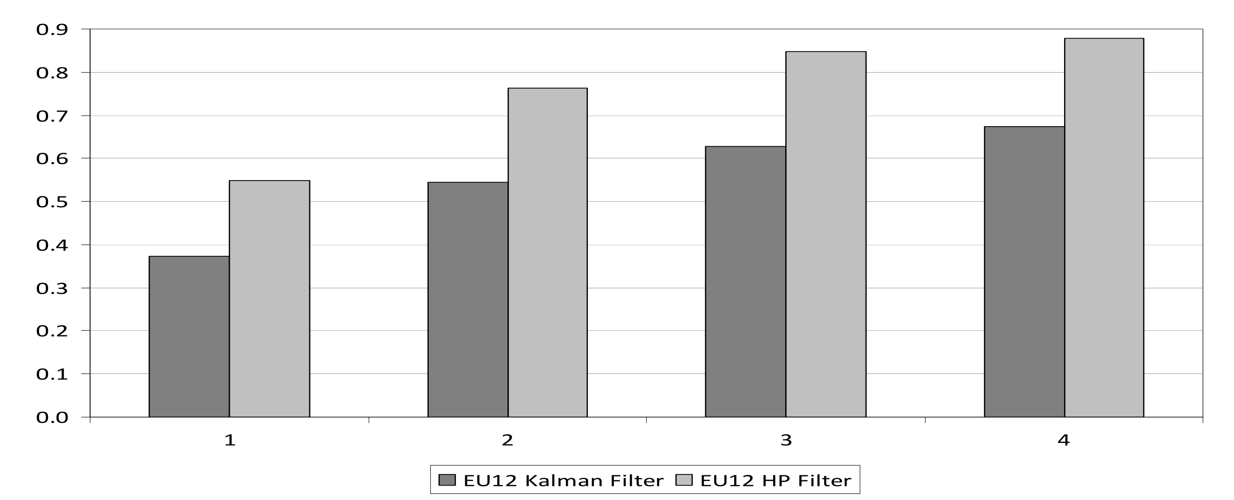
Graph 2.5 : HP & Kalman Filter Estimates of the EU15 TFP cycle for the year 2007 (estimated using real-time vintages over the period 2007-2009)



Source: Commission services

Formal quantification of the "revision" gains from using the KF approach : The above observations, which are based on visual inspections of the data series, can also be formally quantified. Graph 2.6 shows the standard deviations of revisions recorded for EU15 cycle estimates calculated over the period 2000-2008. The revisions are computed on cycle estimates with up to four years of additional data, i.e. the revisions in the cycle estimate for 2000 obtained with the vintages from 2000 until 2004, and so on. The numbers on the x-axis correspond to the number of additional observations. As can be seen, the average standard deviation of the revisions obtained with the bivariate method is considerably smaller than the average standard deviation of revisions for the HP filter, for every considered time-horizon. This indicates that the use of the information content contained in the capacity utilization series reduces, on average, the cycle revisions compared to the HP method.[19] Planas, Roeger and Rossi (2010) formally show that this conclusion is valid for the vast majority of the EU Member States which they examine in their paper.

Graph 2.6 : EU15 - One to four-step-ahead revision standard deviations (x 100)



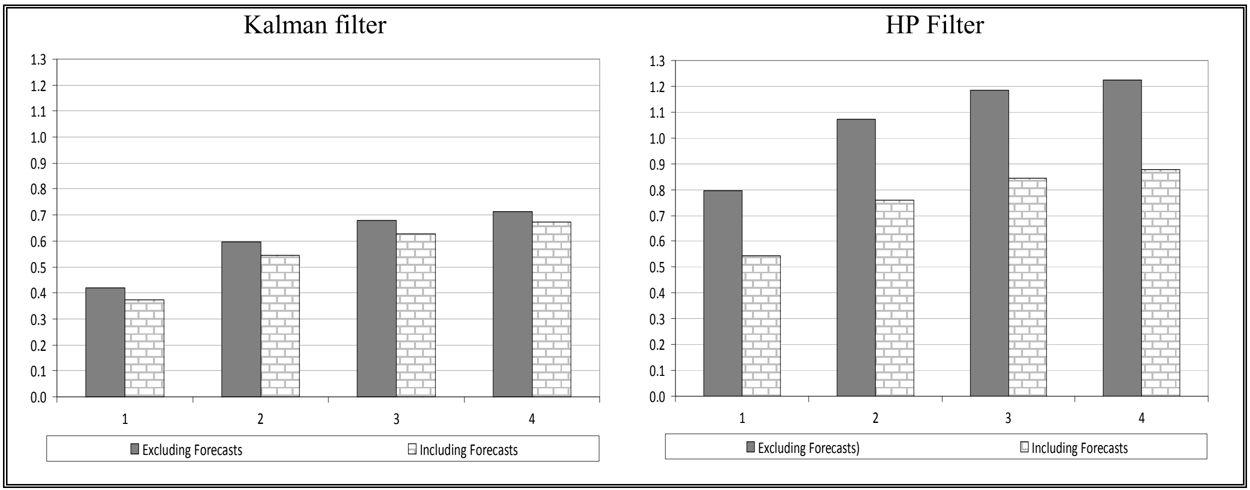
Source: Commission services

The TFP information content in the country desk forecasts of ECFIN : With the objective of assessing the impact of including or excluding ECFIN's short term forecasts from the TFP trend-cycle decomposition, the TFP vintages used at every estimation period are extended with the ECFIN country desk forecasts for the following two years. For example, the 2009 vintages contain preliminary observations for 2010 and 2011. These two points are handled as actual observations in both the HP filter-based method and in the bivariate approach. However, since no such forecasts are available for capacity utilization, the bivariate approach collapses to a univariate model in these two years – see annex 1. The results presented at the December 2009 meeting of the Output Gap Working Group were obtained using these two preliminary estimates. Here we evaluate the value-added of these two forecasts for the TFP trend-cycle decomposition.

Graph 2.7 shows the "revision" standard deviations obtained on data sets with and without these forecasts. Both the bivariate approach and the HP method are considered. As can be seen, for the aggregated EU15 series, there is a clear gain from using the country desk forecasts, regardless of the estimation method applied. Whilst this conclusion may or may not hold for each of the individual member states, on average the forecasts do bring additional information that is useful in the process of TFP trend-cycle extraction. With respect to the individual approaches, the gains to be made for the HP filter from including the forecasts are noticeably greater than for the Kalman filter approach, with this result in part being linked to the end point bias issue discussed earlier. In addition, although the gains from including the forecasts are greatest with the HP filter, graph 2.7 confirms the earlier result from graph 2.6 that whether one includes or excludes the forecasts, the average standard deviation of the revisions obtained with the Kalman filter are consistently smaller than the equivalent statistics for the HP filter.

[19] This observation of course does not rule out that, at a particular date and for a particular series, the revisions in the HP filter estimate do not turn out smaller.

Graph 2.7 : EU15 - One to four-step-ahead revision standard deviations (x 100) including or excluding TFP forecasts



Source: Commission services

Box 2: "Real Time Output Gap Estimates" – new TFP method will lead to a reduction in real time Output Gap revisions.

Revisions to potential output estimates, and even more so for output gaps, have always been a concern amongst users of such information. Although stable estimates are a desirable property of structural estimators, revisions are unavoidable, if only to take into account updates of the information set (revisions and corrections of underlying data and the inclusion of new information)[20]*. In the previous 2006 version of the present Economic Paper, a study of revisions was conducted on pre-2005 vintages, focusing on the accuracy of real-time estimates as measured by the amplitude of the subsequent revisions. The analysis illustrated the overall relative stability of real time potential output estimates over the complete forecast cycle (3 years-6 vintages of forecasts / estimates of the same data values), especially when compared to successive estimates of output (GDP). Revisions in the national accounts data were shown to be the largest source of revisions in output gap estimates, given that revisions to potential output estimates were smaller than revisions of the actual output data.*[21]

This box presents an updated study of revisions to real time estimates. In addition, the likely influence on revisions from the introduction of the bivariate method for TFP trend extraction (which will become the official approach in the Autumn 2010 exercise) is also discussed. More detailed information on the specific issue of revisions to the TFP cycle, comparing the bivariate and univariate methods of trend-cycle decomposition, can be found in Planas, Roeger and Rossi (2010)

Revisions in real time estimates *: Typically, revisions compare either successive data releases with the final release (in the case of published data) or successive forecast / estimated values, obtained at different points in time (in the case of unobserved variables, like potential output and output gaps). These revisions are then aggregated, with a standard measure of their importance being the RMSR –(i.e. root mean square of revisions).*

In table 1, and in order to ensure a consistent approach, revisions are studied across all of the post 2005 vintages, i.e. all vintages corresponding to the production function method as described in the previous Economic Paper. [22] *A simple standard error calculation across all vintages and years gives the results indicated in table 1.*

[20] In addition, the estimated relationships themselves are susceptible to revision, and therefore the update of the information set can possibly have consequences even far back in the estimated series.

[21] Denis et al. (2006), box 1.

[22] Starting with the Autumn 2005 vintage of estimates, until the Autumn 2009 latest vintage, this gives 10 possible data vintages given the bi-annual estimation exercises. We study the revisions in yearly data / estimates for the years 2003 to 2007.

Table 1 : Revisions for all post-2005 vintages

	STANDARD ERROR OF REVISIONS IN THE FOLLOWING 3 SERIES		
	1. POTENTIAL OUTPUT	***2. ACTUAL GDP***	***3. OUTPUT GAP***
BELGIUM	*1.0%*	*1.2%*	*0.8%*
DENMARK	*0.8%*	*0.5%*	*0.9%*
GERMANY	*1.3%*	*1.3%*	*0.6%*
IRELAND	*0.9%*	*1.3%*	*1.8%*
GREECE	*5.0%*	*4.9%*	*0.6%*
SPAIN	*1.5%*	*2.1%*	*1.1%*
FRANCE	*0.8%*	*0.8%*	*0.8%*
ITALY	*0.8%*	*1.1%*	*1.0%*
LUXEMBOURG	*4.4%*	*5.2%*	*1.5%*
NETHERLANDS	*1.9%*	*2.3%*	*0.7%*
AUSTRIA	*0.9%*	*0.8%*	*0.7%*
PORTUGAL	*1.9%*	*2.5%*	*0.9%*
FINLAND	*1.6%*	*1.5%*	*0.9%*
SWEDEN	*1.3%*	*1.8%*	*1.2%*
UK	*0.8%*	*1.4%*	*0.8%*
EU15 (WEIGHTED AVERAGE)	***1.2%***	***1.4%***	***0.9%***

Source: Commission services

Compared to the results from the earlier analysis, several key points emerge. First, on average, and for the vintages and years included in the analysis, the RMSR of all the series are of a higher magnitude than found earlier. A second difference is that, whilst revisions in actual output data are still more important than revisions in potential output, the RMSR for output data and the RMSR for real-time potential output estimates are now closer in magnitude. This holds both on average and for most of the member states. In the same way, and even if output gap revisions remain smaller than revisions in actual and potential output for all countries except Ireland[23], these revisions are nevertheless quite significant.

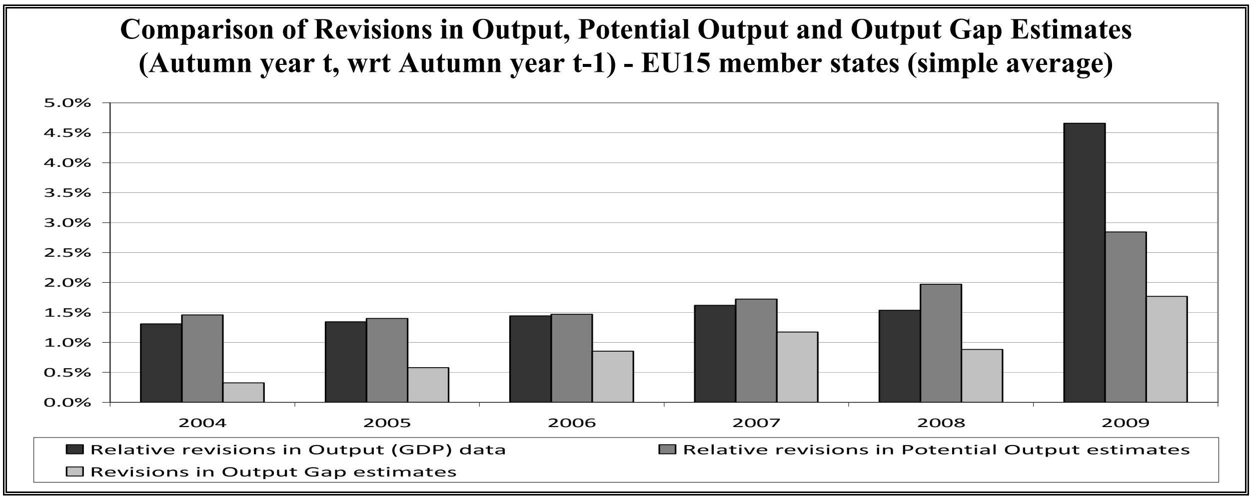
A general explanation for the higher RMSR's is that the introduction of several changes to the SNA methodology (for example, the general move to chain-linked series) has increased the magnitude of the revisions in the underlying SNA series. In addition, the data on hours worked (introduced in the Cobb Douglas PF in 2005) proved to be rather unstable. However, in general, these data revisions trigger revisions in the estimated series in the same direction and of a slightly lower magnitude than the revisions to the underlying series. As revisions in potential output tend therefore to follow the revisions in the SNA data, the ensuing revisions in output gaps are correspondingly much smaller.[24]

Another reason for the higher RMSR's is that the sample studied focussed not only on the more recent years, which are more prone to revisions, but also on the years affected by the financial crisis. In an attempt to better understand what drives the results, average revisions are plotted in the following graph as a function of the year estimated[25].

[23] Several changes occurred for Ireland, especially in the identification model for the TFP trend, which explains the large revisions in potential output estimates and especially in output gaps.

[24] If GDP is revised upwards by 1%, and potential output is revised accordingly by around 1%, by definition the change in the corresponding output gap is bound to be small or negligible. This can also be seen by analogy with the variance decomposition of the difference, which gets smaller, the larger the correlation between the terms of the difference.

[25] The measure of revisions used in this graph is not directly comparable with the one used in the table where all of the available vintages are employed for a given point estimate. In the graph, the analysis on revisions focuses on "the year after" – i.e. with one more year of information. Besides, only simple averages of the member state results are used and shown.



Source: Commission services

As could be expected in a very uncertain environment, the revisions are indeed larger following the crisis, for both the actual and potential output series. Revisions in output gap estimates remain small, but principally for the earlier years. The larger revisions afterwards can be linked with the well-known uncertainty at turning points, especially given the optimistic and persistent nature of the TFP trend estimates obtained by HP filtering. One can also notice the high magnitude of the revisions for the 2007 estimate of output gaps, which results from, firstly, the general optimism of the initial estimates[26]*, and, secondly, from the effect of the subsequent crisis in further pulling down the potential output estimates via a " neighbourhood" effect.*

***Impact on revisions from the shift to a Kalman Filter based trend TFP methodology** : The delay in recognizing a turning point is a characteristic feature of purely statistical / univariate smoothing techniques, such as the HP filter. Although the main idea of the production function is to move away from univariate statistical methods for the estimation of structural output, an important component of potential output remains trend TFP, which up to now has been extracted by HP filtering.*

The change towards a bivariate method for the extraction of trend TFP is supported by the information about the cycle which is given by a supplementary indicator (i.e. capacity utilisation). This new method helps in avoiding both an overestimation of trend TFP in "good" times and an underestimation in "bad" times. Planas Roeger and Rossi (2010) have shown that for all member states, the bivariate method outperforms the HP method for real-time TFP gap estimates. They document large reductions in the magnitude of the revisions when the bivariate method for extracting the TFP cycle is compared with the univariate HP method used in the production function prior to 2010. For most countries (BE, DE, DK, ES, FR, IT, NL, PT), the bivariate method, on average, produces at least 50% smaller revisions when assessed over short run horizons. The same is true at longer horizons and even in a wide variety of other cases, the reduction in revisions is sizeable.

As the TFP gap forms an essential element of the output gap, it is to be expected that any improvements obtained by adopting the bivariate method for estimating the TFP gap would translate into less frequently, and less severely, revised output gaps. On that basis, the constructed measures of the gains to be obtained in the magnitude of the revisions from using the bivariate method are presented in table 2.

Table 2 - Average reduction (%) in revisions from switching to Kalman Filter trend TFP extraction method*

	BE	*DE*	*DK*	*EL*	*ES*	*FR*	*IE*	*IT*	*NL*	*PT*	*UK*
TFP gap (1-year horizon)	*24%*	*31%*	*39%*	*49%*	*34%*	*19%*	*26%*	*43%*	*8%*	*32%*	*2%*
Output gap (1-year horizon)	*17%*	*21%*	*44%*	*12%*	*8%*	*16%*	*19%*	*46%*	*2%*	*33%*	*8%*

**(1-ratio of RMSR)*
Source: Commission services

[26] As documented, for example in notes to the OGWG, the return to average property of the TFP trend estimates leads, in good economic times, to initial medium-term estimates that are usually on the optimistic side and are subsequently revised downwards.

To sum up, the history of revisions shows that the agreed method for estimating output gaps performs relatively well when compared to actual data revisions, and in particular that potential output estimates, and especially output gap estimates, are more stable (less prone to revisions) than the underlying GDP data series itself. However, the recent financial crisis has also "stress-tested" the method from the data viewpoint. This experience highlighted a number of specific problems, most notably emanating from the ongoing dependency of the overall estimates on univariate (HP filter) derived series, particularly for trend TFP extraction.[27] It is encouraging to note that a lot of these TFP related problems will be removed with the introduction of the recently agreed bivariate method for TFP trend / cycle decomposition. The new TFP method will result in significantly smaller revisions to output gaps, with an average gain, at 1-year horizons, of as much as 20% expected for most countries.

[27] Other aspects of the recent crisis in relation to potential output are discussed elsewhere in this paper.

SECTION 3 : CALCULATING STRUCTURAL UNEMPLOYMENT RATES – THE NAWRU METHODOLOGY

3.1 : NAWRU METHODOLOGY FOR THE "OLD" MEMBER STATES

The so called "Non-Accelerating Wage Rate of Unemployment" or NAWRU is widely accepted as an equilibrium concept for the labour market. The NAWRU is implicitly defined as the equilibrium point of a dynamic system of labour supply and labour demand equations. This equilibrium concept is linked to the Phillips curve debate which is crucial in monetary policy discussions. Since the famous Phelps (1967) and Friedman (1968) contributions in the late 1960s, a consensus has emerged that with long run flexible prices and wages, there should be no long run trade-off between the rate of inflation and the rate of unemployment. Consequently, wage and price dynamics must be formulated in terms of changes in wage and price inflation. With this formulation it is assured that the unemployment rate will always return to its equilibrium value, regardless of the level of the long run (wage) inflation rate. This is the rationale behind the NAWRU / NAIRU (non-accelerating inflation rate of unemployment) concepts.

Using a standard bargaining model of the labour market under the assumption of static or adaptive expectations (see Annex 2 for a more detailed discussion of the model), a relationship between the change in nominal wage inflation and the unemployment gap can be derived which is controlled for by the change in the growth rate of labour productivity, the wage share and the terms of trade[28].

The dynamics of the Phillips curve reflects the process through which wages adjust to economic conditions. Wage adjustment can be delayed because of limited information in the formation of expectations or because of institutional rigidities. For modelling expectations, a backward looking framework is used, in particular a distinction is made between static and adaptive expectations. Different expectations schemes generate different dynamics of the Phillips curve and it turns out that one can capture the heterogeneity of the Phillips curve dynamics in the EU with these two schemes.

Static (Moving average) vs Adaptive Expectations : Static expectations is the simplest expectation scheme (see Blanchard and Katz (1999)). Under this scheme, expectations for period t are simply equal to the realisation of the respective variable in period t-1. This scheme appears reasonable for quarterly data. Applying such a scheme to annual data requires a slight modification, namely a moving average scheme over current and lagged inflation. Such a scheme can also approximate to an overlapping contracts specification. Concerning wage formation, the two crucial variables for which expectations must be formed are inflation (π) and labour productivity (*pr*) :

$$\pi_t^e = a\pi_t + (1-a)\pi_{t-1} \quad (1a)$$

$$\Delta pr_t^e = c\Delta pr_t + (1-c)\Delta pr_{t-1}. \quad (1b)$$

[28] Due to data availability issues, a simpler model and a different estimation technique is used for estimating the NAWRU's for the "new" member states (see section 3.2).

The degree of nominal rigidity is proportional to (1-a) while the degree of real rigidity is proportional to (1-c). Combining these expectations schemes with the structural model of the labour market yields the following Phillips curve :

$$\Delta^2 w_t = \phi^{pr}\Delta^2(pr_t) + \phi^{ws}\Delta^2 ws_t + \phi^{tot}\Delta^2 tot_t - \beta(u_t - nairu_t) + v_t^w \quad (2)$$

where *w* is the log of nominal wages, *pr* is the log of labour productivity, *ws* is the log of the wage share, *tot* is the log of the terms of trade, and *u* is the unemployment rate.

The Phillips curve shows the short run response of nominal wages to labour productivity, labour demand shocks and the unemployment gap. The response to the unemployment gap is intuitively plausible. Whenever unemployment is above the NAIRU, nominal wage growth will decelerate and vice versa. However, this link is not perfect but is disturbed by observed and unobserved shocks to the wage rule and to the labour demand equation. How nominal wage growth responds to productivity and labour demand shocks (here approximated by changes in the growth rate of the wage share) depends on a variety of factors. This is discussed in more detail in annex 2.

The above specification applies to the majority of countries in the EU (see Table 3.1) and in particular to the Euro Area aggregate as well as to the US. However in some countries, in particular Denmark, Italy, the Netherlands and the UK, the unemployment gap appears with a quasi first or second difference in the Phillips curve. This cannot be generated with the static expectations scheme. One needs to assume adaptive expectations of the following form :

$$\pi_t^e = a\pi_{t-1} + (1-a)\pi_{t-1}^e \quad (3a)$$

$$\Delta pr_t^e = c\Delta pr_{t-1} + (1-c)\Delta pr_{t-1}^e . \quad (3b)$$

or a combination between adaptive and static expectations. Assuming adaptive inflation and static productivity expectations yields :

$$\Delta^2 w_t = \sum_{i=0}^{1}\phi_i^{pr}\Delta^2 pr_{t-i} + \sum_{i=0}^{1}\phi_i^{ws}\Delta^2 ws_{t-i} + \sum_{i=0}^{1}\phi_i^{tot}\Delta^2 tot_{t-i} - \beta\left[(u_t - nairu_t) - (1-a)(u_{t-1} - nairu_{t-1})\right] + v_t^w \quad (4)$$

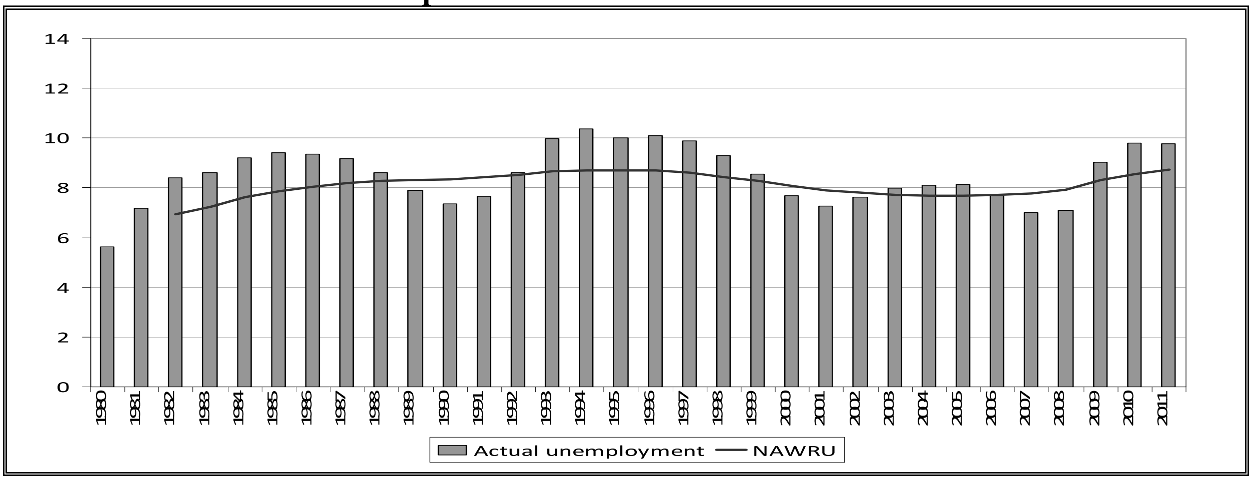
while the combination of adaptive inflation and adaptive productivity expectations yields :

$$\begin{aligned}\Delta^2 w_t = &\sum_{i=0}^{2} c_i\Delta^2 pr_{t-i} + \sum_{i=0}^{2} c_i\Delta^2 ws_{t-i} + \sum_{i=0}^{2} c_i\Delta^2 tot_{t-i} - \\ &\beta\left[(u_t - nairu_t) - (2-a-c)(u_{t-1} - nairu_{t-1}) + (1-c)(u_{t-2} - nairu_{t-2})\right] + v_t^w\end{aligned} \quad (5)$$

Application of the method : Graph 3.1 shows the evolution of the NAWRU for the EU15 aggregate since the early 1980s. It shows that this group of countries collectively experienced an increase in their structural unemployment rate over the 1980's and early 1990's. From around the mid to late 1990's, the NAWRU fell consistently up until the start of the current financial crisis. This pattern with respect to the NAWRU performance of the EU15 as a whole is not replicated for all of its constituent member states (see graphs in annex 2). For example some countries experienced a steady increase in structural unemployment, at least up until the pre-financial crisis period, as was the case for Austria and Germany.

The reasons behind the cross-country variations in NAWRU performances can be identified by an analysis of structural changes in labour and product market conditions, such as the level of the tax wedge, the generosity of unemployment benefits, the degree of product market regulations and the user cost of capital (see, for example, Nickell et al., 2005, and Gianella et al., 2009). As an example, increases in the tax wedge appear to have considerably contributed to the increase in the Austrian NAWRU / NAIRU, whilst cuts in the average benefit replacement ratio have been identified as drivers of the decrease in structural unemployment in the UK. In the case of Germany, moreover, a vital factor in explaining the increase in the NAWRU / NAIRU was the unification-related structural break.

Graph 3.1: EU15 - NAWRU estimates



Source: Commission services

At the cross-country level, an important factor influencing the evolution of the NAWRU / NAIRU is the degree of nominal rigidity in labour markets, with this factor affecting the speed of adjustment to changing economic conditions. Wages in the European Union have been estimated to change on average every 15 months by Druant et al. (2009) within the Eurosystem Wage Dynamics Network project. In order to take account of nominal rigidities, a hybrid New Keynesian Phillips curve, incorporating expected inflation, can be estimated (see Vogel, 2008). Vogel suggests that the NAIRU has shifted considerably with the business cycle and with economic shocks during the estimation period, with actual unemployment rates fluctuating around their natural rate.

In addition to supply-side determinants, many studies argue that structural unemployment is affected by factors influencing aggregate demand through hysteresis mechanisms. Hysteresis in the labour market implies that long periods of high unemployment translate into an increase in the NAWRU / NAIRU. This is due to the fact that the long-term unemployed have a smaller influence on labour market dynamics as they become less appealing to potential employers (see Box 3 for a further discussion). Ball (2009) ascribes, to a large extent, the evolution of the NAWRU / NAIRU since the early 1980s in OECD countries to hysteresis phenomena. The empirical evidence is however mixed. Various techniques can be applied to test for the presence of such effects. On the basis of unit root tests, Leon-Ledesma (2002) does not find support for the hypothesis of hysteresis in unemployment in the European Union. Jaeger and Parkinson (1994) and Logeay and Tobin (2006), on the contrary, use Kalman-filter techniques and find evidence of hysteresis, respectively, in Germany, the UK and in the Euro Area labour market as a whole.

Table 3.1: Phillips Curve Estimates

	$\Delta^2 PROD$	$\Delta^2 TOT$	$\Delta^2 TOT(-1)$	$\Delta^2 WS$	*U-GAP*	*U-GAP(-1)*	*U-GAP(-2)*	ΔU	*R**2*	*Q-Statistic, p-value*
BE	0.39 (3.29)	0.16 (0.86)			-1.20 (2.90)				0.26	0.49
DE	0.56 (3.29)				-0.88 (2.55)				0.21	0.22
DK	0.53 (4.02)		0.08 (0.64)	0.80 (8.32)		-0.27 (1.21)			0.62	0.68
ES	0.38 (2.18)		0.59 (2.95)	0.50 (3.17)	-0.43 (2.73)				0.41	0.84
FR	0.73 (3.34)	0.13 (0.79)	0.49 (3.26)	0.93 (5.80)	-0.36 (1.82)				0.54	0.33
GR	0.61 (4.19)		0.10 (0.54)	0.63 (5.44)	-0.66 (1.31)				0.42	0.28
IR	0.09 (0.58)		0.44 (3.70)		-0.75 (1.89)				0.37	0.78
IT		0.08 (0.29)			-3.26 (3.82)	5.10 (3.58)	-2.28 (2.43)		0.02	0.58
LX	0.28 (2.75)		0.03 (0.22)		-0.93 (2.83)				0.31	0.62
NL	0.53 (3.15)			0.61 (4.80)	-0.12 (0.45)	-0.36 (1.23)			0.38	0.79
OS	0.51 (3.82)		0.07 (0.51)	0.76 (7.20)	-0.87 (2.28)				0.65	0.90
PO	0.06 (0.23)		0.41 (1.31)		-0.76 (1.05)				0.08	0.01
SF	0.19 (1.02)				-0.37 (1.15)			-0.74 (2.27)	0.30	0.67
SW	0.48 (2.73)			0.85 (6.44)	-0.30 (2.49)				0.55	0.99
UK			0.92 (2.82)		-2.34 (3.00)	1.22 (1.69)			0.30	0.18
EURO AREA (EU12) and the US										
Euro Area	0.16 (1.01)	0.06 (0.30)	0.12 (0.57)		-0.70 (3.28)				0.13	0.32
US	0.28 (2.51)	0.34 (1.30)	0.14 (0.51)		-0.44 (2.36)				0.16	0.76

Notes : Kalman filter estimates over the period 1965-2011. Estimation is performed with annual data, including the short term forecast of DG ECFIN. See C. Planas et al (2004) for a description of the program used.

Table 3.1 reports the Kalman Filter estimates of the Phillips curve for the "old" EU15 member states, the Euro Area and the US. Due to data limitations, this approach cannot be applied to the new member states (the approach adopted for these countries is described in section 3.2). The coefficient on the unemployment gap is found to be robustly significant for almost all member states, lending support to the model specification. Moreover, in nearly all of the countries, changes in productivity have a significant impact on changes in wage inflation. The terms of trade also appear to play a role in explaining nominal wage changes, which respond to the wedge between consumer price and GDP inflation with a lag. Compared to the previous estimates, reported in Denis et al (2006), there is no evidence of a common tendency in the overall evolution of the Phillips curve relationship across member states over recent years. However, it can be observed that for a number of countries, such as Germany, the relationship between wage inflation and the unemployment gap appears to be stronger.

3.2 : NAWRU METHODOLOGY FOR THE "NEW" MEMBER STATES

In calculating the NAWRU estimates for the "New" Member States, the same theoretical specification, as described earlier in section 3.1, is essentially used. However, some simplifying assumptions are employed in order to facilitate the process.

For the estimation process, a methodology proposed by the OECD (i.e. the “Elmeskov” method) forms the central element of the approach.[29] However, instead of applying the methodology to nominal wages, it is applied to nominal unit labour costs. This gives a specification for the Phillips curve which is close to the model with static expectations :

$$\Delta^2 ulc = \Delta^2 w_t - (\Delta^2 y_t - \Delta^2 l_t) = -\beta(u_t - nairu) + u_t^w - u_{t-1}^l \qquad (6)$$

This formulation indicates that unemployment is below the NAIRU / NAWRU whenever the growth rate of unit labour costs increases.

Using the methodology described in annex 2, initial estimates of β were obtained which were close to those obtained for the EU15 member states. These parameter values were therefore used in the first estimation exercises after accession.[30]

With more information becoming available on the link between unit labour costs and unemployment (as well as on the functioning of the labour market in these countries), β estimates were updated on the basis of longer time series for unemployment and unit labour costs. Starting in 2007, and in a comparable manner to that of the EU15 countries (where the complete model is re-estimated each time that a different information set is used), the coefficient is now evaluated at the beginning of each new forecasting exercise. The method uses a grid search in the vicinity of the previous estimate, reiterated until convergence is reached.[31]

[29] J. Elmeskov (1993) - see annex 2 for additional information.
[30] See table 2.2 in Denis et al (2006) for the values obtained.
[31] More details on the procedure followed are provided in Annex 2.

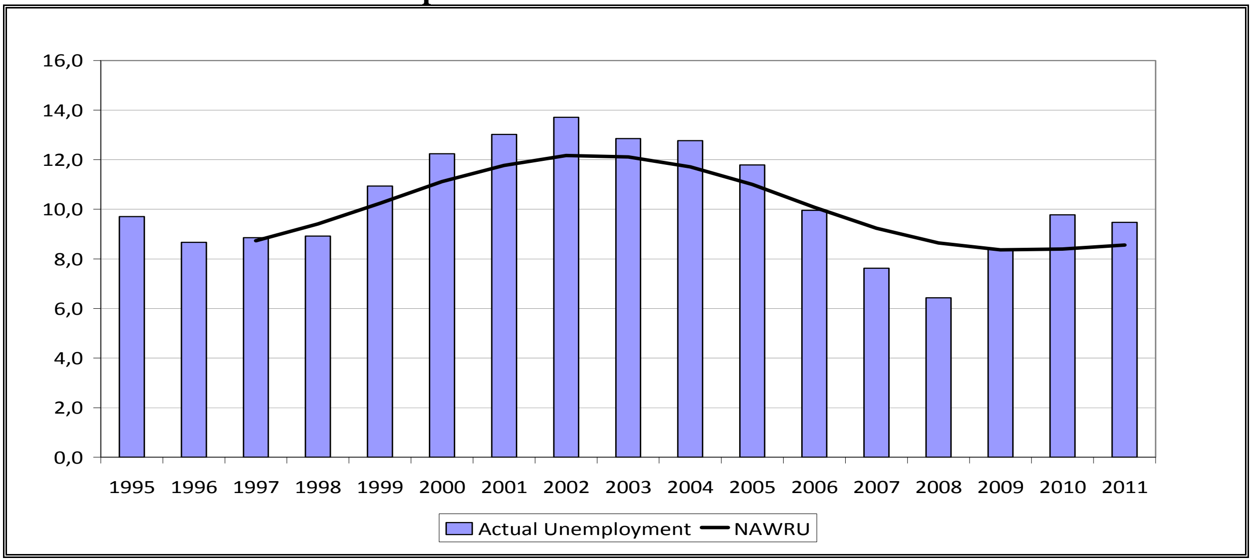
Table 3.2: Estimates of the Wage Elasticity Parameter

	β_{ULC}
Cyprus	1.6
Czech Republic	1.35
Estonia	2.25
Hungary	2.25
Latvia	5.0*
Lithuania	1.65
Malta	2.54
Poland	5.0*
Slovakia	1.5* (0.6)
Slovenia	2.5
Bulgaria	**
Romania	6.0

* see text below
Source: Commission services

Table 3.2 gives the estimates of the reduced form coefficient for the 12 "new" member states, obtained using this method during the recent Spring 2010 estimation exercise. The results for some countries merit special discussion. The Baltic countries, Slovakia and Poland are especially characterized by large swings in the unemployment rate and a strong deceleration in unit labour costs at the beginning of the period. For these countries the use of the "Elmeskov" method is difficult. For Poland and Latvia, the coefficient is arbitrarily fixed at 5, ensuring that the NAWRU is still influenced by the evolution of unit labour costs but is closer to a "simple" HP filtered unemployment rate. For Slovakia, the method explained above would have resulted in an estimate of 0.6 but this coefficient value would have produced an unrealistically low NAWRU at the end of the period. The NAWRU estimates for Bulgaria are actually obtained through simple HP filtering. Graph 3.2 gives the current NAWRU estimates, obtained using this method, for an aggregate of the 12 "new" member states for the period 1995-2011 (graphs for the individual EU12 countries are shown in annex 2).

Graph 3.2: EU12 - NAWRU estimates



Source: Commission services

Box 3 : An assessment of the impact of the financial crisis on structural unemployment in the EU

As discussed earlier in box 1, the financial crisis is expected to have an impact on potential output mainly through slower capital accumulation and a reduction in the growth contribution of labour. With respect to the latter, a recession usually translates into a temporary increase in the NAWRU, affected by changes in actual unemployment in the presence of nominal rigidities and a slow adaptation of the economy to the sectoral reallocation process required. Over the medium run, however, the NAWRU should return to its pre-crisis level unless structural changes occur in the labour market.

Table 1 reports NAWRU estimates and projections for the individual "old" and "new" member states as well as for their respective EU15 and EU12 aggregates. These estimates have been obtained using the methods described in sections 3.1 and 3.2. The significant short run rise in the NAWRU experienced in many countries follows the strong increase in actual unemployment across the EU.

Whether the increase in the NAWRU will persist in the long-run depends on a series of factors:

- *Firstly, there is evidence that the level of the tax wedge and the generosity of unemployment benefits are important drivers of structural unemployment (see for example Gianella et al., 2009), as they persistently affect the wage setting mechanism. A combination of overly generous unemployment benefit regimes and a rise in labour taxes could slow down the transition in the labour market, leading to a lasting increase in structural unemployment.*

- *A second risk associated with the current crisis is that of a durable increase in risk premia. This would reduce firms' profit margins and in turn increase the NAIRU / NAWRU as firms increase their mark-ups to recoup the higher cost of capital.*

- *Lastly, long-term unemployment may cause a permanent destruction in human capital, leading to an irreversible rise in the NAWRU and to further losses in the potential output level. The long-term unemployed experience a deterioration in their employability due to an inability to use their professional skills, often aggravated by the stigma effect from the viewpoint of employers. Unlike the short-term unemployed, they can no longer compete with those in a job and consequently do not exert any dampening effect on the wage claims of the incumbents. This would give rise to the process of "hysteresis in unemployment" identified by Blanchard and Summers (1989).*

Overall, in the absence of a persistent increase in the cost of capital or a deterioration in the institutional setting, the NAIRU / NAWRU should go back to its original level with no impact on potential output in the long-run. A temporary acceleration in potential growth when the crisis unwinds should offset the temporary deceleration in growth during the crisis. However, if labour market institutions become more inefficient and/or the cost of capital becomes permanently higher, the temporary rise in structural unemployment could be more long-lasting, which would give rise to a durable loss in the potential output level.

TABLE 1: NAWRU ESTIMATES FOR THE 27 EU MEMBER STATES (2000-2011)

"OLD" EU15 MEMBER STATES NAWRU ESTIMATES (% OF LABOUR FORCE) – KALMAN FILTER METHODOLOGY															
	AT	*BE*	*DE*	*DK*	*EL*	*ES*	*FI*	*FR*	*IE*	*IT*	*LU*	*NL*	*PT*	*SE*	*UK*	*EU15*
2000-2006	*4.2*	*7.8*	*8.6*	*4.7*	*9.6*	*10.8*	*8.3*	*9.3*	*4.2*	*8.6*	*3.6*	*3.0*	*5.9*	*6.5*	*5.2*	*7.8*
2007	4.5	7.8	8.4	4.5	9.7	10.8	7.4	9.0	5.8	7.9	4.7	3.2	7.7	6.7	5.5	7.8
2008	4.4	7.8	8.3	4.3	9.6	11.9	7.2	9.0	7.1	7.9	5.1	3.3	8.0	6.8	5.8	7.9
2009	4.7	8.0	8.1	4.7	10.1	14.0	7.6	9.0	9.2	7.9	5.3	3.5	8.8	7.5	6.3	8.3
2010	4.8	8.2	7.9	4.7	10.6	15.2	7.8	9.1	10.9	8.0	5.6	3.9	9.1	7.8	6.7	8.5
2011	5.1	8.4	7.6	4.7	11.0	16.4	7.6	9.1	12.5	7.8	5.9	4.2	9.5	7.9	7.0	8.7

"NEW" EU12 MEMBER STATES NAWRU ESTIMATES (% OF LABOUR FORCE) – VARIANTS OF THE ELMESKOV METHODOLOGY													
	BG	*CZ*	*EE*	*CY*	*LV*	*LT*	*HU*	*MT*	*PL*	*RO*	*SI*	*SK*	*EU12*
2000-2006	*13.6*	*7.3*	*9.8*	*4.3*	*11.0*	*11.8*	*6.1*	*7.2*	*16.5*	*6.5*	*6.2*	*16.5*	*11.4*
2007	*8.1*	*6.5*	*7.8*	*4.7*	*9.2*	*8.0*	*7.6*	*6.9*	*12.2*	*6.8*	*5.7*	*12.9*	*9.2*
2008	*7.3*	*6.4*	*8.4*	*5.0*	*10.7*	*8.5*	*8.3*	*6.8*	*10.4*	*6.8*	*5.7*	*12.3*	*8.6*
2009	*6.9*	*6.6*	*9.8*	*5.5*	*13.1*	*10.1*	*9.0*	*6.8*	*9.2*	*6.8*	*5.9*	*12.1*	*8.4*
2010	*6.7*	*7.0*	*11.8*	*5.8*	*16.2*	*12.4*	*9.8*	*6.8*	*8.4*	*7.0*	*6.1*	*12.2*	*8.4*
2011	*6.7*	*7.7*	*14.2*	*6.2*	*19.4*	*13.8*	*10.6*	*6.8*	*7.7*	*7.2*	*6.5*	*12.5*	*8.6*

Source: Commission services

SECTION 4 : THE CONTRIBUTION OF CAPITAL TO POTENTIAL GROWTH – ONGOING RESEARCH WORK

This section will mainly focus on where the weaknesses have been with the capital accumulation side of the methodology and where future research work will be focussed in order to address these concerns.

4.1 DISAGGREGATING THE CAPITAL STOCK INTO ITS HOUSING AND NON-HOUSING COMPONENTS : In this part of the section, we look at the feasibility and impact of disaggregating the overall capital stock of EU economies into housing (i.e. "residential structures") and non-housing components. The overall objective is to explore the possibility of improving that part of the production function (PF) methodology which is used for estimating the contribution of capital to potential output, with the present section being structured as follows. Section 4.1.1 gives a brief overview of the current approach to handling investment / capital stock trends in the PF method, as well as highlighting the possible problems with that approach. Section 4.1.2 presents a tentative proposal for the introduction of a housing / non-housing breakdown of the capital stock in the existing method. Section 4.1.3 gives an overview of the results of the new disaggregated capital stock methodology for all of the EU's member states. Finally, the concluding remarks section (4.1.4) underlines the key points to be retained from the analysis.

4.1.1. Overview of present approach and of its limitations : The current PF method takes the total capital stock into account. In terms of the measurement of the capital stock, the perpetual inventory method is used which makes an initial assumption regarding the size of the capital / output ratio and accumulates annually all investments (GFCF), whilst discounting a fraction of the existing stock via an annual depreciation rate :

$$K_t = I_t + (1 - dep_t)K_{t-1}$$

Since the stock of capital is assumed not to be subject to cyclical fluctuations, any (increase in) investment directly enters the production function and is translated into (an increase of) potential output.[32] In addition, since all types of capital goods, from machinery to various forms of residential and non-residential buildings / infrastructure, are considered together as one aggregate, consequently we are implicitly calculating the average productivity of the capital stock as a whole rather than the productivity of individual components. In the absence of large composition shifts in the type of investments taking place, the current approach generally does not lead to any major biases in the estimation of potential growth nor in its evolution over time. However, once the relative proportions of housing to non-housing investments change significantly, as they have done over recent years for a large number of EU member states (with the bulk of the increase in economy-wide investments being due to housing investments), the use of the existing production function may bias the estimate of potential output via the following two channels :

- Firstly, it is implicitly assumed that the new investments will contribute to potential output "in the same way" as other net investments to the existing capital stock, that is with the same productivity trend. However, if the composition of the capital stock

[32] The use of the capital stock, but not the stock itself, is affected by the cycle, and that is measured by the rate of capacity utilisation. The potential capital stock is equal to the total existing stock of capital.

shifts decisively towards either housing or non-housing investments over an extended period of time, the observed past average productivity effect may not be the correct efficiency factor to be used. In these circumstances, the present approach produces a direct contemporaneous effect which tends to over- / underestimate the potential output impact corresponding to the new capital stock, with knock-on implications for the size of the estimated output gap.

- Secondly, there is another effect which is spread over longer periods of time and which operates via the total factor productivity (TFP) channel. Given that the current TFP component in the PF method is smoothed over time, with the aim of removing cyclical and erratic movements, the capital compositional effects described above could produce TFP trends which are an under / over – estimate of the "true" trend TFP.

4.1.2. A modified production function which explicitly takes into account the accumulated stock of residential structures ("housing") : The proposed change to the PF method takes into account the distinction between "housing" and other types of investments, including construction of non-housing structures, machinery and other equipment. In the national accounts, changes in the housing stock affect GDP through the rents channel, including imputed rents for self-owned housing. The proposed change to the PF method is essentially driven by the observation that the output elasticity of housing, as proxied by actual and imputed rental income, produces a rate of return on "housing" which is significantly different from the average output elasticity of capital of 0.35 which is embedded in the present PF method. In fact, our estimates suggest that the rate of return on housing is significantly lower than that of non-housing investments, with this return differential justifying the present proposal to modify the PF method. In order to estimate and use an alternative PF specification, we need :

- Firstly, to clearly establish the link between the housing capital stock and the revenues counterpart of these accumulated investments in GDP.

- Secondly, data series for the housing stock in the respective countries need to be built, with the latter necessitating a thorough investigation of the possible data sources to be used in applying the standard perpetual inventory method employed in the literature. At a minimum, to construct a housing stock series, the perpetual inventory method needs an (initial) estimate of the housing stock, as well as housing-specific depreciation rates and investment series[33].

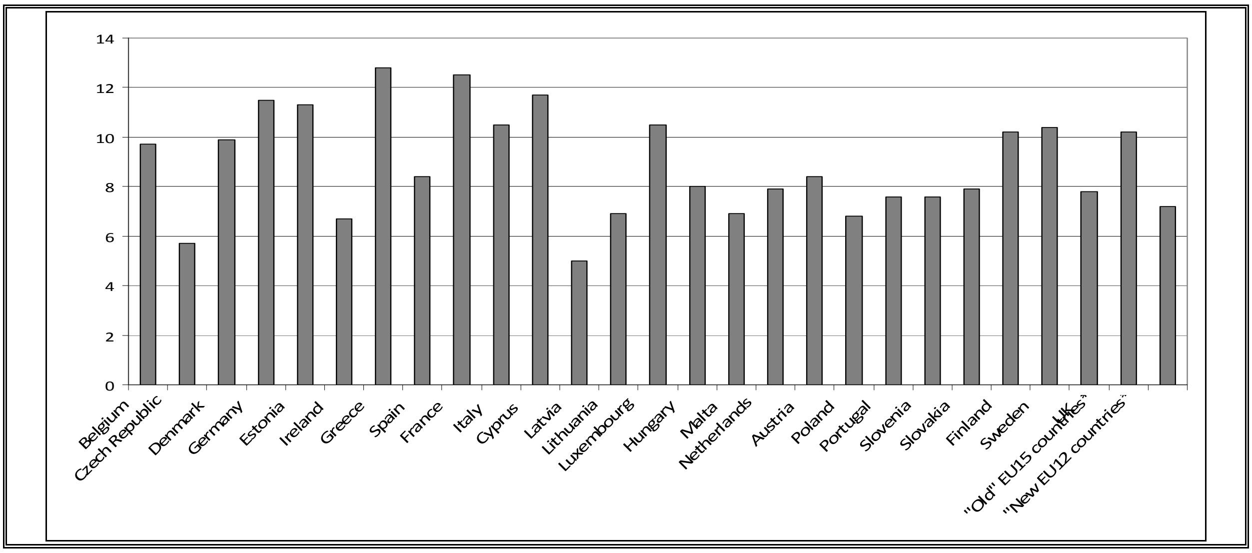
4.1.2.1. How do changes in the housing capital stock affect GDP / output ? : Housing services are produced from the stock of housing capital, with the value of these services being reflected in GDP. The value of these housing services are estimated in the national accounts using both actual market rents (which are a good approximation of the value of the services generated by the rented housing stock) and the imputed rents estimated for the owner occupied housing stock. Rents must be imputed for those households living in owner-occupied housing since they do not pay a market price for the housing services which they

[33] Historical data on gross investment in housing is the essential basic ingredient for the estimation of a housing capital stock series. In the steady state, neoclassical growth theory assumes that investment & capital grows at the same rate & consequently the growth rate of capital can be approximated by the investment growth rate.

consume. These "imputed" / “notional” housing services transactions are valued in the national accounts using the "rental equivalence" approach[34], which essentially involves estimating what homeowners would have paid for a similar property, in a similar area, in the house-rental market. Actual and imputed rents are added together to provide an estimate of the total output of housing services, with the value added of these services equal to total output less intermediate consumption (i.e. an estimate of the expenses associated with housing such as current maintenance and repair costs, insurance services etc). Value added in turn is made up of the operating surplus accruing to the housing stock (i.e. the profit or loss from the rental business as a whole) as well as housing related depreciation and capital taxes. Housing services are included on the production side of the national accounts in the "real estate activities" industry which corresponds to ISIC[35] code 70 and on the expenditure side under household final consumption expenditures.

Table 4.1 shows the average value added share for the "real estate activities" industry for most of the EU's Member States for the periods 1981-1995 and 1996-2005 (with the individual year 2001 also included for comparison with the rental expenditures data which is only available for 2001). The data is taken from the EU KLEMS database, with the table (and graph 4.1) showing that over the period 1996-2005 that the value added of the housing services industry ranged from lows of 5% / 6% in countries such as Latvia & the Czech Republic to highs of 12% / 13% in countries such as Germany, Greece, France and Cyprus. The average value added share for the 25 countries for which data is available suggests that housing services contributed roughly 10% to the total value added of this group of countries. Compared with the earlier 1981-1995 period, for the 15 countries where such a comparison is possible, there is clear evidence that the value added share is rising over time, with the gain over the period in question being 2% points.

Graph 4.1 : Average 1996-2005 value added shares for the "Real Estate Activities" Industry (%)



*Weighted average based on the maximum number of relevant countries.
Source : EU KLEMS

[34] Other methods for estimating the imputed rental income from owner-occupied housing include firstly, the user-cost of capital approach or secondly, a method which simply applies a rate of return to the house value & uses this as an indication of the income foregone (i.e. the opportunity cost) if this equity capital had been invested in some other investment such as an interest-bearing deposit account.

[35] International Standard Industrial Classification

Table 4.1 : Housing Services : Production and Expenditure Based Measures

	"Real Estate Activities" / Housing Services (% Share of Value Added / GDP)			Total Housing Rental Expenditures[36] (% Share of GDP)	Imputed Rents (% Share of Total Rental Expenditures)	Owner-Occupied Housing Stock (% Share of Total Housing Stock)
	1981-1995	1996-2005	(2001)	2001	2001	2000
Belgium	9.4	9.7	(9.9)	8.8	72.4	73
Czech Republic		5.7	(6.2)			
Denmark	9.9	9.9	(10.0)	8.7	64.6	65
Germany	9.1	11.5	(11.5)	9.9	54.0	43
Estonia		11.3	(12.4)			
Ireland	5.6	6.7	(7.1)	7.3	86.0	82
Greece	11.2	12.8	(12.2)	8.9	83.0	84
Spain	6.8	8.4	(8.1)	6.2	88.9	85
France	10.2	12.5	(12.6)	9.1	72.8	63
Italy	8.0	10.5	(10.3)	8.2	82.3	75
Cyprus		11.7	(11.2)			
Latvia		5.0	(6.4)			
Lithuania		6.9	(7.0)			
Luxembourg	9.1	10.5	(10.9)	8.1		
Hungary		8.0	(8.4)			
Malta		6.9	(6.6)			
Netherlands	6.7	7.9	(8.1)	6.8	61.2	53
Austria	6.5	8.4	(8.2)	7.0	76.9	54
Poland		6.8	(6.5)			
Portugal	7.2	7.6	(7.3)	4.4	85.0	65
Slovenia		7.6	(7.8)			
Slovakia		7.9	(8.9)			
Finland	8.1	10.2	(9.9)	11.1	71.5	68
Sweden	9.2	10.4	(10.2)	10.6	60.5	60
UK	5.1	7.8	(8.3)	8.4	69.8	71
"Old" EU15 countries*	8.2	10.2	(10.2)	8.6	69.9	63.2
"New" EU12 countries*		7.2	(7.2)			

*Weighted average based on the maximum number of relevant countries in each individual column.
Source : EU KLEMS, OECD

[36] Actual rentals for housing plus imputed rents for owner-occupied housing.

With respect to the expenditure side of the national accounts, data with regard to total housing rental expenditures are unfortunately only available for 15 of the EU's member states and estimates exist for just one year (i.e. 2001). In principle the value added and expenditure measures of housing services should be equivalent. This is not the case in Table 4.1 since not all of the value added of the real estate industry can be attributed to capital compensation (i.e. rents) from housing stock investments, with the EU KLEMS capital compensation data suggesting that about 80%-90% of the value added of this industry is essentially rental income. If this EU KLEMS estimate is broadly correct, then the production and expenditure measures for housing services would both suggest that total rents from the housing capital stock are equivalent to about 8%-9% of EU GDP.

Table 4.1 also provides a breakdown of the rental expenditures in 2001 into the shares emanating from both market-based rents and imputed rents as well as an estimate of the owner-occupied housing stock as a share of the total housing stock for the year 2000. Whilst this additional information is a bit dated, it does nevertheless underline the very large differences across countries with respect to housing market structures, with the share of imputed rents ranging from a low of 54% in Germany[37] to almost 90% in Spain. Given these differences in the degree to which imputational procedures are used to measure housing services, one must be careful not to underestimate the international comparability concerns which clearly attach to (national accounts-based) housing statistics, although for the EU KLEMS datasets used in the present paper, the research consortium partners have tried to ensure a minimum degree of comparability across countries.

4.1.2.2. Building national series of housing stock and housing investments (EU KLEMS & AMECO data sources) : Whilst section 4.1.2.1 has discussed the links between changes in the housing capital stock and GDP, it is clear that in order to be able to reflect this link in the PF method, the first essential step is the construction of national housing stock series. In order to do this using the perpetual inventory method, as mentioned earlier, we need at least a point estimate of the housing stock, as well as housing specific investment and depreciation rate series.

- **Housing stock** : For a small group of 8 countries (i.e. Austria, Germany, Denmark, Finland, the Netherlands, Portugal, Sweden and the United Kingdom), we can take the housing stock data directly from EU KLEMS[38] – with annual data normally being available for the period 1976-2005[39]. In the EU KLEMS databank, housing capital is totally allocated to the "Real Estate Activities" industry (ISIC 70), with a preliminary data analysis showing that around 80%-90% of the value added stemming from this

[37] The low share for imputed rents in Germany may be an argument in favour of using the German data as a more reliable indicator of the "real" value added share of housing services in EU economies. If this is true then the implication is that housing services tend to be underestimated in a significant number of EU countries.

[38] EUKLEMS gives a breakdown, at the industry level, of the capital stock into 7 different asset types. 3 of the latter are ICT assets (namely computing equipment; communications equipment; and software) and 4 of them are non-ICT assets (transport equipment; other machinery and equipment; residential structures; and non-residential structures). EU KLEMS uses the asset depreciation rates which have been calculated by the US Bureau of Economic Analysis (BEA) and applies these in a harmonised way across the countries. Whilst there is no country variation, depreciation rates do differ by asset type and by industry, with rates ranging from .011 for residential structures up to .315 for computing equipment (implying that whilst computer equipment is technologically obsolete after only a few years, residential structures can continue to provide annual capital service flows for close to 90 years). For our purposes here, we use the "total industries" series for "residential structures" from EU KLEMS for the 8 countries mentioned in the text since this is equivalent to the total economy housing stock in these economies.

[39] The series for Sweden start in 1993; for Portugal in 1995; and for Germany the series is in two parts, due to reunification.

industry takes the form of capital compensation for housing stock investments. In addition, all of the capital compensation from (total economy) investments in housing are included in this single "Real Estate Activities" industry.

- **Investment series** : For the investment series, we use the gross fixed capital formation in "dwellings" series from AMECO[40] - DG ECFIN's annual macro-economic database. Whilst an identical housing investment series exists in EU KLEMS, the AMECO series has a number of important advantages which makes its use appealing for the present exercise. Firstly, AMECO has data which goes well beyond the EU KLEMS end year of 2005 - it presently contains data up to 2011 since it includes the forecast values for housing investment from the Commission services Spring 2010 short-term forecasting exercise. Furthermore, and very importantly with respect to the feasibility of introducing the "modified" PF method, AMECO includes housing investment series for most of the EU27 Member States (which is a substantially greater number than that currently available in EU KLEMS) - see table 6 in annex 5.

- **Depreciation** : For the housing depreciation[41] rate, we estimate the implicit rate using the "total industries" housing capital stock from EU KLEMS and the housing investment series from AMECO[42] (but only for the 8 countries mentioned earlier).

Calculating Housing Depreciation Rates / Housing Capital Stock Estimates for Non-EU KLEMS Member States : Whilst investment series are available for all of the 27 EU Member States from AMECO, as explained earlier we only have housing depreciation rates and capital stock estimates from EU KLEMS for 8 of the 27 countries. Consequently, for the remaining EU member states, we are obliged to use the available EU KLEMS datasets to set the following default values for these two crucial variables :

- ***Depreciation rates*** : The implicit depreciation rates estimated using both the housing capital stock (source : EU KLEMS) and housing investment series (source : AMECO) are shown in table 4.2. The values obtained are consistent with the average housing depreciation rate of 1.1% quoted in the EUKLEMS "Methodology Manual"[43] which translates into an average housing depreciation time span of roughly 90 years (compared, for example, with a depreciation rate assumption of around 3 years for computing equipment). This annual average 1.1% depreciation rate for housing is the one used as the default value when an implicit depreciation rate cannot be calculated for individual countries and years.

[40] AMECO has disaggregated investment series by type of investment goods. The basic decomposition is between “Machinery and Equipment” and “Construction”, with the latter in turn further broken down into “dwellings” and “non-residential” investments. It is the investments in "dwellings" (i.e. housing) which we use for our calculations.

[41] i.e. the consumption of the fixed housing capital stock

[42] This derived implicit rate of depreciation is virtually identical to the depreciation rate series included in EU KLEMS.

[43] http://www.euklems.net/data/EUKLEMS_Growth_and_Productivity_Accounts_Part_I_Methodology.pdf

Table 4.2 : Implied Depreciation rates

	1981-1995	1996-2005
Austria	1.14	1.14
Germany		1.14
Denmark	1.04	1.24
Finland	1.20	1.14
Netherlands	1.31	1.07
Portugal		1.04
Sweden		1.14
UK	1.14	1.13
Weighted Average	1.14	1.14

Source : EU KLEMS, AMECO, own calculations

- ***Housing stock*** : For the countries not covered in EU KLEMS, an initial value of the housing stock is also needed in addition to the annual depreciation rate. To fill this gap, we took the average value of the ratio of housing capital to total capital for those countries in EU KLEMS where data was available and we chose the first value (usually 1976[44]) as the reference value. As table 4.3 highlights, for all countries except Germany (where the value of the ratio is close to 55%), housing has a 1976 share of between 35% to 40% of the overall capital stock, with an average value of 41% if one includes all of the available countries. Consequently, for the purposes of the present calculations, we assumed an initial value of the housing stock in 1976 for those countries with no housing stock series which was equal to 40% of the total capital stock. We then used the perpetual inventory method to generate the capital stock series using this initial capital stock value, along with the AMECO series of housing investment and a housing depreciation rate equal to 1.1%.

Table 4.3 : Share of Building Capital Stock in Total Capital Stock

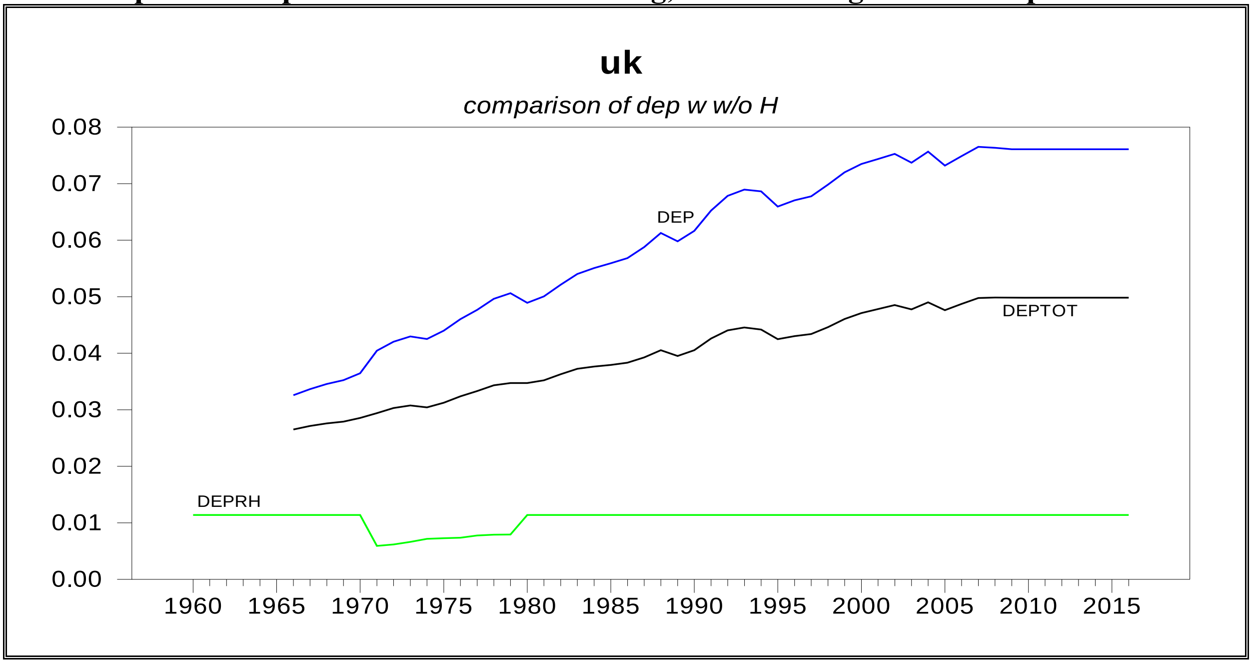
	1976 (Initial Value of Housing Capital Stock Share)	1981-1995	1996-2005
Austria	0.35	0.38	0.41
Germany	0.55	0.54	0.52
Denmark	0.37	0.41	0.42
Finland	0.35	0.40	0.42
Netherlands	0.38	0.42	0.43
Portugal			0.31
Sweden			0.30
UK	0.35	0.39	0.37
Weighted Average	0.41	0.43	0.44

Source : EU KLEMS

[44] We used the earliest starting date possible since the likelihood that the perpetual inventory method would generate inaccurate gross capital stock estimates diminishes the further we are away from the initial reference value.

Calculating "Non-Residential" Capital Stock Estimates: From the existing series of the (total) capital stock, and the series for the housing stock just calculated, one can infer the series of "non-residential" capital stock, by difference. Investment series for non-housing are also obtained by difference (between the total gross fixed capital formation series and the investment in dwellings series). This in turn, gives us, the implied depreciation rate for the non-housing stock. With an overall depreciation rate of around 5% and an assumed housing depreciation rate of 1,1%, the depreciation rate for the non-housing stock varies around 8% - depending on the composition of the remaining investments and capital stock (see graph 4.2).

Graph 4.2 : Depreciation rates for Housing, Non-Housing & Total Capital Stock



Source : EU KLEMS, AMECO, own calculations

For the "new" Member States, the problem is a bit more complicated since there is no series for the (total) capital stock one could refer to. For our purposes (estimation of potential output through a similar Production Function approach) the capital stock series were built on the basis of the (total) investment series, using a default depreciation rate of 5% and an initial capital-output ratio. In this exploratory analysis, we have further built on these assumptions : the initial housing ratio (housing stock over total capital stock) in 1995 is fixed to 45%; the default depreciation rate for the housing stock is kept at 1,1%, while we fix the depreciation rate for non-housing assets at 7,5% (and let the overall depreciation rate vary, instead of fixing it to 5% and let the depreciation rate for non-housing assets vary). More assumptions and default values are therefore used for the "new" member states than for the remaining countries. In addition, the shorter length of the series renders the influence of those assumptions more "visible" over recent years. The provision of country-specific assumptions or information would therefore very much improve the quality of the results in the case of these member states.

4.1.2.3. A modified specification of the production function which explicitly takes housing investments into account : Following the discussion in 4.1.2.2 on data issues, the present section looks at the proposed alternative specification for the production function. An alternative model for capital accumulation is specified to take into account the split between housing and non-housing capital goods (see box 4 for more details). The essential features of the modified model are given below, with the total capital stock being split between K, the non-residential capital stock and KH, the housing stock (K+KH = total capital stock), with the KH part entering the production function multiplied by the efficiency parameter γ : [45]

$$YPOT_t = LPOT_t^{\alpha}(K_t + \gamma KH_t)^{1-\alpha} APOT_t$$
$$K_t = I_{K,t} + (1 - dep_{K,t})K_{t-1}$$
$$I_{K,t} = iypot_{K,t} YPOT_t$$
$$KH_t = I_{KH,t} + (1 - dep_{KH,t})KH_{t-1}$$
$$I_{KH,t} = iypot_{KH,t} YPOT_t$$

With the total capital stock (K) disaggregated into housing *(KH*) and non-housing *(K*), total investment is also disaggregated into I_K and I_{KH}, and the equations governing the evolution of the capital stock are duplicated. The evolution of $iypot_{KH}$ and $iypot_K$ follow an AR process, like *iypot* in the present version of the agreed PF method.

With respect to the value of the γ parameter, the analysis in Box 4 indicates that a value of 0.3 seems appropriate[46]. This implies that housing capital has an efficiency level which is, on average, only 30% of that of non-housing, which in turn would imply an output elasticity for housing investments of around 0.08 / 0.09 (i.e. a total rental income from the EU's housing capital stock of 8% / 9% of GDP). In order to assess the sensitivity of the results to the value of the γ parameter, annex 5 table 5 (using the example of the United Kingdom) compares the results for the modified methodology using the proposed value of 0.3, with the results when parameter values of 0.1 and 0.65 are used respectively[47].

4.1.3. What is the impact of the new approach on the potential growth and output gap estimates for the EU's member states ? : Table 4.4 summarises the main changes for the EU's member states which a shift to the new methodology would imply for potential growth and output gap developments. The capital stock, depreciation rate and investment series for housing which are used for the calculations are those discussed in the previous section, with the value of the γ parameter set at 0.3. The main general conclusions to be drawn from table 4.4 are as follows :

- The disaggregation of the capital stock into housing and non-housing only modifies the TFP and the capital components of potential output, with the labour component unaffected by the proposed change. In terms of the overall impact on potential growth, the modified methodology produces effects on capital accumulation and TFP which tend to offset each other, with the result that the overall average impact on EU potential growth rates is generally small. With respect to the changes for countries

[45] One could even discuss the idea of an additive production function, which for practical purposes would mean applying the same production function on economic variables which have been "cleaned up" from their housing part i.e. one would remove housing investments from gross fixed capital formation; the housing stock from the capital stock; and finally the revenues stemming from housing from the GDP figures.

[46] It can be noted that the commonly agreed method uses a production function which is a special case of the alternative one proposed here, with γ=1.

[47] Such a sensitivity analysis is important since some studies in the literature put the efficiency parameter as high as 0.5 – see, for example, the article by E.S. Mills (Princeton University & Federal Reserve Bank of Philadelphia) "Has the United States overinvested in Housing" in Real Estate Economics", Volume 15, Issue 1, pages 601-616.

such as Spain, where housing investment has been a particularly strong contributor to the overall, post-2000, surge in investment, the use of the modified PF methodology results in surprisingly small effects with, for example, a higher TFP contribution of 0.05 in 2005, an offsetting lower capital accumulation contribution of -0.06, and consequently an almost zero overall impact on potential growth[48].

- With respect to the "old" EU15 member states, the generally positive effects on the contribution of TFP to potential growth from using the modified methodology reflects the revision of the productivity estimate due to the compositional shifts. The lower productivity of housing investment is now explicitly included in the expression of the production function (factor gamma), and TFP is a more direct measure of the productivity of the non-residential part of the capital stock, and less of a compound effect. As can be observed in table 4.4, the TFP contribution is therefore on average higher, although the cases of Luxembourg and Sweden shows that this pattern is far from universal. With respect to the variation of the estimated TFP effects over time, this is also influenced by shifts in the respective shares of housing and non-housing in the overall capital stock[49], with the medium-term TFP path now being more closely linked to developments with respect to non-housing investments[50].

- The changes in the capital accumulation contribution from using the modified specification can be broken down into a variety of effects. These effects reflect the fact that although the capital stock which is now taken into account in the production function has been recalculated, the rules for its accumulation over time have also changed. For example, whilst the economic importance of housing investments are de facto reduced by the gamma parameter, there is an offsetting phenomenon in that changes in the housing stock now have more "persistent" effects since the housing depreciation rate is lower than the average for the other types of capital goods[51].

- In general, the changes for the "new" member states are more pronounced than for the former EU15 countries. As stated before, this is linked to the shorter length of the series, which magnifies the impact of the initial assumptions, and to the more pronounced reliance on general assumptions (with little data to infer from). Improvements can clearly be expected from more "tailor-made" assumptions or from the provision of specific data series.

[48] Whilst the effects on Spain may be small, the housing / non-housing split is nevertheless warranted since it results in more economically plausible TFP patterns, with trend TFP growth rates no longer going below zero.

[49] This compositional effect is smoothed over time (HP filter).

[50] With respect to the present crisis, once the credit channel has been repaired, there will hopefully be a strong recovery in non-housing investments and, with the proposed change to the present PF specification, this should lead to a stronger impact on medium to long run TFP trends.

[51] With the housing part of the capital stock (which accounts for about 40% of the total) having a depreciation rate of 1.1%, this implies that the non-housing part has a higher depreciation rate than previously assumed since the national accounts sourced depreciation rate for the total capital stock has not changed.

Table 4.4 : Difference between the potential growth and output gap estimates under the alternative specification and under the "normal" PF method

		Potential growth	*K accumulation contribution*	*TFP contribution*	*Output Gap*
Austria	2000	0.04	0.01	0.03	0.08
	2005	0.03	0.02	0.01	-0.02
	2010	-0.04	-0.06	0.04	-0.06
Belgium	2000	0.05	-0.11	0.16	-0.04
	2005	-0.04	-0.19	0.16	0.09
	2010	-0.03	-0.17	0.14	0.01
Cyprus	2000	0,06	0,04	0,02	-0,01
	2005	-0,17	-0,17	0,00	0,14
	2010	0,07	0,11	-0,04	-0,10
Czech Rep.	2000	-0,03	0,27	-0,29	-0,10
	2005	-0,03	0,14	-0,17	-0,07
	2010	-0,11	0,01	-0,12	0,20
Denmark	2000	0.02	-0.19	0.21	-0.03
	2005	-0.04	-0.32	0.28	0.00
	2010	0.00	-0.30	0.31	0.10
Germany	2000	0.07	-0.10	0.17	-0.04
	2005	-0.05	-0.20	0.16	0.15
	2010	-0.01	-0.14	0.13	-0.03
Finland	2000	0.01	-0.24	0.25	0.10
	2005	-0.08	-0.27	0.19	0.11
	2010	0.13	-0.04	0.16	-0.24
France	2000	0.05	-0.01	0.06	0.02
	2005	0.00	-0.04	0.04	0.03
	2010	0.03	-0.06	0.09	-0.17
Ireland	2000	0.06	-0.10	0.16	-0.12
	2005	-0.08	-0.19	0.11	0.23
	2010	0.06	-0.03	0.09	-0.21
Italy	2000	0.04	-0.03	0.07	0.05
	2005	0.00	-0.09	0.09	-0.07
	2010	-0.04	-0.17	0.14	0.03
Lithuania	2000	-0,17	0,30	-0,46	-0,17
	2005	0,01	0,30	-0,28	-0,11
	2010	-0,32	-0,14	-0,18	0,41
Luxembourg	2000	-0.03	0.31	-0.33	0.06
	2005	0.04	0.35	-0.30	-0.23
	2010	-0.08	0.05	-0.13	-0.08
Netherlands	2000	0.07	-0.08	0.15	-0.12
	2005	-0.10	-0.26	0.17	0.11
	2010	0.04	-0.13	0.18	-0.08
Poland	2000	0,07	0,40	-0,32	-0,56
	2005	-0,12	0,03	-0,14	0,17
	2010	-0,04	-0,10	-0,14	0,15
Slovakia	2000	-0,40	-0,07	-0,32	-0,34
	2005	0,00	0,14	-0,14	0,18
	2010	-0,10	0,01	-0,11	0,16
Slovenia	2000	0,09	0,47	-0,37	-0,23
	2005	-0,08	0,12	-0,19	-0,13
	2010	-0,21	-0,10	-0,11	0,36
Spain	2000	0.02	-0.01	0.03	-0.04
	2005	-0.02	-0.06	0.05	0.06
	2010	0.01	-0.03	0.04	-0.02
Sweden	2000	0.04	0.19	-0.15	-0.14
	2005	-0.02	0.09	-0.11	-0.00
	2010	-0.02	0.03	-0.05	-0.05
United Kingdom	2000	0.05	0.11	-0.07	-0.03
	2005	0.01	0.07	-0.06	-0.02
	2010	-0.02	-0.02	0.00	-0.08

Source: Commission services

4.1.4 Concluding remarks : This analysis is very much a tentative first effort towards assessing the implications of having a more disaggregated capital stock in the PF methodology. Using the capital stock and depreciation rate series for housing from EU KLEMS, as well the investment series from AMECO, the paper shows the feasibility of introducing such a housing / non-housing capital stock disaggregation into the present approach. In addition, whilst it is accepted that some of the parameter estimates need to be revised somewhat, the analysis confirms the intuitively sensible conclusion that housing investment has a substantially lower rate of return compared with non-housing. The estimated effect from these differences in efficiency on the present estimates for potential growth are, however, on average quite small (except for a number of the "new" member states where some of the assumptions used will need to be re-examined on the basis of more country-specific data series).

Box 4 : Differentiating housing and non-housing capital in the PF method

The following production function is postulated :

(B.1) $$Y_t = L_t^{\alpha}(K_t + \gamma KH_t)^{1-\alpha} A_t$$

In this formulation, we allow the efficiency (γ) of the residential capital stock (KH) to differ from corporate and government capital (K). So far we only have to calibrate the parameter α , the output elasticity of labour, by using information about the wage share and we derive the output elasticity of capital by using the assumption of constant returns to scale. Furthermore, in the current specification, we implicitly assume $\gamma = 1$ (i.e. the housing and non-housing capital stock has the same output elasticity). We do not use information available from total rents (actual plus imputed rents) to fix the efficiency of residential capital. However, rents generated by residential capital should be linked to the marginal efficiency of residential structures (i.e. housing) under the assumption of a competitive housing market.

Suppose there is a real estate sector which invests in KH in order to provide housing services. With a well functioning capital market, the rental price of residential capital (P_t^R) is equal to :

(B.2) $$P_t^R = (i_t - \inf_{t+1}^H + \delta_t^H) P_t^H$$

i.e. the real estate sector requires an annual return which is equal to the nominal interest rate (i_t) minus the capital gain (per cent increase in the house price ($\inf_{t+1}^H$)) plus the rate of depreciation of residential capital (δ_t^H), multiplied with the house price index (P_t^H) and the following marginal condition must hold :

(B.3) $$\frac{\partial Y}{\partial H} = (1-\alpha)\gamma \frac{Y_t}{(K_t + \gamma KH_t)} = \frac{P_t^R}{P_t^Y}$$

Since we know the ratio of residential capital to total capital ($r_{HKTOT} = KH / KTOT$) and the share of total rental income to GDP ($s_{RY} = (P^R H)/(P^Y Y)$), we can rearrange eq B.3 as follows :

(B.4) $$(1-\alpha)\gamma \frac{r_{HKTOT,t}}{(1+\gamma r_{HKTOT,t})} = s_{RY,t}$$

Solving eq B.4 for γ , we find that r_{HKTOT} is roughly .4[52] and s_{RY} (i.e. actual and imputed rents) is around 8% - 9% of GDP, which gives a value for the efficiency parameter of .3, given our choice of $\alpha = .35$.

Obviously eq. B.1 is not the only possible functional form that could be chosen but eq. B.1 has the advantage that the current formulation emerges as a special case, when $\gamma = 1$.

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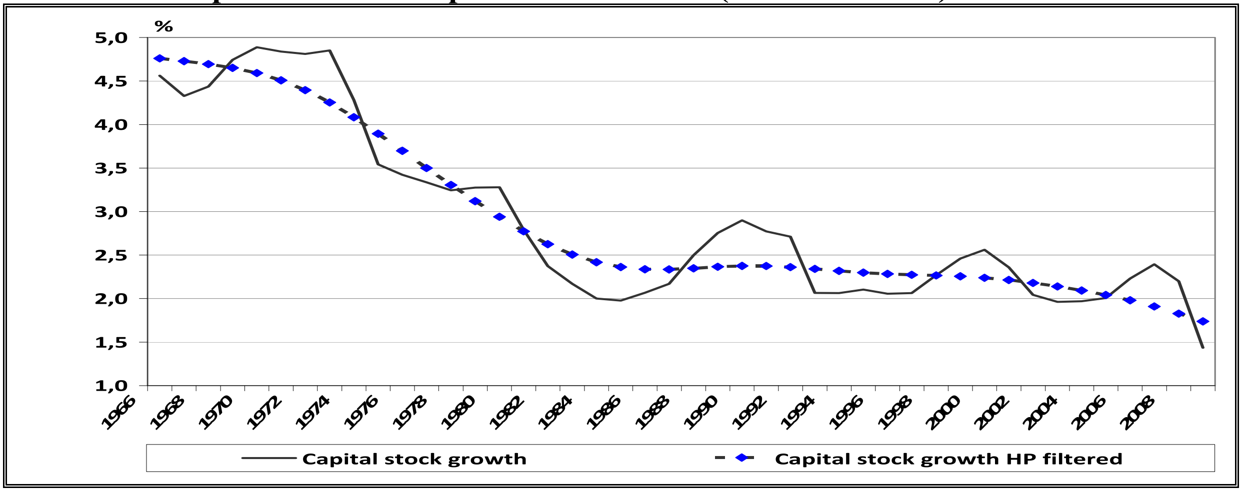
52 i.e. the housing capital stock is, on average, roughly equivalent to 40% of the total capital stock.

4.2 : STRUCTURAL DETERMINANTS OF THE CAPITAL STOCK

The current production function approach calculates potential by using the employment / hours worked trend and the TFP trend, but uses an actual, instead of a trend, capital stock for calculating potential output.

If one looks at potential output in a more static way – namely as a characterisation of current production capacity, then it is certainly justified to take the capital stock as given. However, if one has a more dynamic concept of potential output in mind, then one can ask the question, whether the current capital stock is consistent with economic fundamentals or whether it is likely that the capital stock will be adjusted in the future. Capital misalignment can for example happen if too much capital was accumulated because of a housing bubble or a stock price bubble (see graph 4.3).

Graph 4.3 : EU* - Capital Stock Growth (Actual + Trend) 1966-2009



*Original Euro Area countries
Source: Commission services

Since both the previous boom and recession, as well as the current financial crisis, are closely related to asset market / investment boom and bust cycles, it seems appropriate to ask whether the PF methodology can be extended in order to shed more light on deviations of capital accumulation from its long run fundamental trend.

Indeed the PF approach offers some possibilities for assessing deviations of the capital stock from its fundamental position. To carry out such an exercise, one simply has to look at the desired capital stock that is implied by a profit maximising firm given the production technology.

The first order condition determines the capital stock by equating the marginal product of capital to capital costs :

$$(1-\alpha)\frac{Y}{K} = (1-\alpha)TFP\left(\frac{L}{K}\right)^{\alpha} = cc, \qquad cc = \frac{(i-\inf^{I}+\delta)}{(1-tc)}\frac{PI}{P}$$

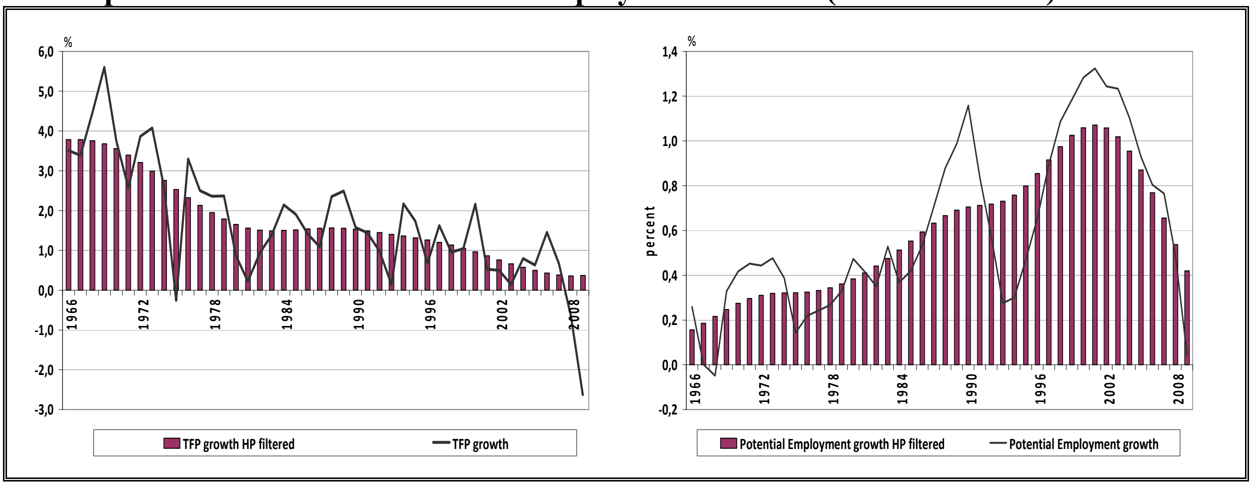
This relationship should at least hold in the long run, while in the short run deviations can occur because of adjustment lags for capital. This efficiency condition in turn defines a trend for the capital stock (K^T), as given by the trend of TFP, the labour trend and the trend in capital costs :

$$K^T = (TFP^T)^{1/\alpha} L^T (cc^T)^{-1/\alpha}$$

The current PF approach already determines two of the three factors, namely trend TFP and trend labour input. Therefore, provided information about trend capital costs can be obtained[53], a trend capital stock, which is consistent with 'fundamental' trends in technical progress, labour supply and capital costs, can be calculated (see graphs 4.4 & 4.5).

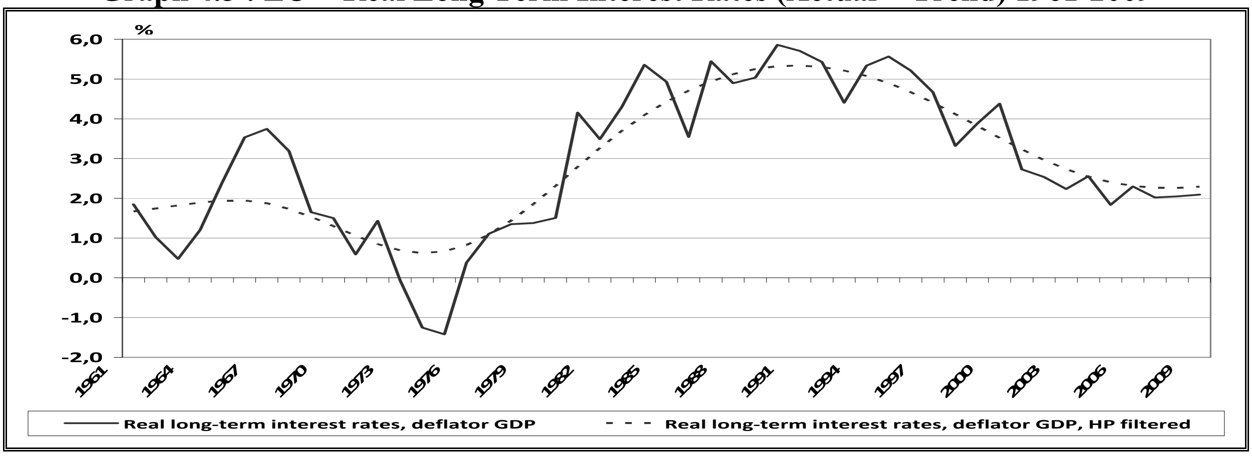
Comparing this concept of trend capital to actual capital can be useful since it might signal whether investment rates over a certain period of time are consistent with underlying technological and labour market trends plus an assessment of long term real interest rates.

Graph 4.4 : EU* -TFP & Potential Employment Growth (Actual + Trend) 1966-2009



*Original Euro Area countries
Source: Commission services

Graph 4.5 : EU* -Real Long Term Interest Rates (Actual + Trend) 1961-2009



*Aggregate of BE, DE, FR, IT, NL & FI
Source: Commission services

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[53] In order to calculate capital costs it is necessary to obtain information about loan interest rates, the relative price of investment over GDP, plus information about the taxation of capital. Apart from the data issues related to calculating capital costs it will also be necessary to come up with an acceptable concept of trend capital cost, i.e. one needs an assessment on whether capital costs are unusually low or high in a given period, e.g. in a bubble period, capital costs may appear unusually low because of high inflation rates for investment.

Box 5 : Capital stock depreciation rates and the impact of the financial crisis

Overview of concept *: In order to arrive at a genuine measure of the new wealth created in an economy during a specific period, a deduction has to be made for the cost of using up capital. This is known as consumption of fixed capital (i.e. what economists refer to as "depreciation). Consumption of fixed capital is defined in the national accounts as "the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage". The fixed assets include dwellings, buildings, transport equipment and physical infrastructure. This definition of depreciation is based on the national accounts concept of income[54] and consequently, unlike a more economic definition of income, does not allow for price changes (holding gains and losses) in the value of fixed or financial assets. The national accounts definition focusses instead on capturing the effects of a reduction in the value of capital due firstly to normal "wear and tear" and secondly due to the effects of obsolescence. Obsolescence can be defined as a process whereby a capital good goes out of use, out of date or experiences a decline in its capacity to generate returns for reasons other than "wear and tear". For example, the appearance of a new vintage of capital goods may render existing goods obsolete, not because they change the physical characteristics of the old vintage but because their economic usefulness is reduced. The effects of obsolescence is captured in the national accounts by allowing for reduced service lives and shifting age-price and / or age-efficiency functions for different asset classes.*

Measures of economic growth adjusted for depreciation *: When depreciation is deducted from GDP (Gross Domestic Product) or GNI (Gross National Income), the result is NDP (Net Domestic Product) and NNI (Net National Income). In theory, NDP and NNI are better measures than GDP and GNI of the wealth or income created because they deduct the cost of using up capital assets. However, economists tend to prefer GDP or GNI (over NDP and NNI) for two reasons. Firstly, the methods for calculating the consumption of fixed capital are complex and tend to differ between countries, thus creating doubts about the international comparability of results[55]. Secondly, when ranking countries or analysing growth, the differences between GDP and NDP are generally small and consequently do not change the overall conclusions. The word generally is important here since as table 1 indicates, the differences between GNI and NNI can be significant for individual years and specific countries. Whilst in the case of the US and the Euro Area, the differences between gross and net income growth rates are small and tend to cancel each other out over time, this has not been the case for Japan where significant and sustained, negative, differences occurred over the 1990's.*

What could explain this persistently high level of depreciation in Japan over the 1990's ? Whilst interpreting differences between gross and net income flows is difficult, it is reasonably clear that physical wastage of assets could not be the driving factor. The higher than average losses in the value of Japanese fixed assets is much more likely to be explained by the effects of technological obsolescence linked to the rise in the average vintage or age of the Japanese capital stock over this period. The idea that most technological progress is embodied in new capital equipment, and that the benefit of new technology is not realized without introducing new vintages of capital, has been around since the 1960's but this idea may be especially pertinent in explaining the growing gap between GNI and NNI in Japan in the 1990's. The particularly weak pattern of investment in Japan in the 1990's, especially with respect to the newer ICT technologies, has ensured that the replacement of old capital equipment with newer vintages has progressed at a historically slow pace, leading to the observed higher capital obsolescence rate.

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[54] The national accounts define income as the flow of net resources arising directly, or through redistribution, from normal productive activities and potentially available for consumption (i.e broadly the notion of disposable income). On the other hand, some economists (Hicks in particular) define income as the maximum sum that can be consumed in a given period without reducing a household's real net worth (net worth is the difference between a household's assets and liabilities; real net worth is this difference deflated by the price index for final consumption). Consequently, capital gains and losses linked to changes in the prices either of fixed assets (notably housing) or of financial assets (notably shares) form part of the Hicksian definition of income but not the national accounts definition of income.

[55] National accountants calculate the consumption of fixed capital using the "perpetual inventory method" or PIM. However, since it involves numerous assumptions regarding service lives and rates of depreciation, some statistical offices prefer to publish incomplete accounting balances (gross and not net) on the grounds that they are more reliable, instead of the net figures that are more correct but less reliable.

Table 1 : Gross National Income (GNI) and Net National Income (NNI) trends in Japan, the US and the Euro Area (1990-2008) (Annual + Period Average % Changes)

	Japan		***US***		***Euro Area***	
	GNI	***NNI***	***GNI***	***NNI***	***GNI***	***NNI***
1990	***7.7***	***7.5***	***5.9***	***5.9***	***n.a***	***n.a***
1991	***6.4***	***5.7***	***3.2***	***2.8***	***n.a***	***n.a***
1992	***2.8***	***2.0***	***5.7***	***5.9***	***5.3***	***5.1***
1993	***0.8***	***0.2***	***5.1***	***5.3***	***1.2***	***0.8***
1994	***0.4***	***0.0***	***6.1***	***5.9***	***4.1***	***4.1***
1995	***1.4***	***1.2***	***4.7***	***4.6***	***4.8***	***4.9***
1992-2002	***0.5***	***0.1***	***5.2***	***5.1***	***3.9***	***3.8***
2003-2008	***0.9***	***0.8***	***5.5***	***5.5***	***4.1***	***4.0***

Source: Commission services

What are the likely effects of the financial crisis on depreciation rates ? *: At the outset, it is important to stress that the national accounts definition of capital depreciation only takes physical wastage and obsolescence into account – future EU depreciation rates will not therefore be adjusted for the recent substantial capital losses associated with falls in the market prices of a wide range of property and financial assets (these losses will instead be reflected in the "revaluation" account). Consequently, the effects of the financial crisis on depreciation rates are likely to be indirect rather than direct. For example, based on the lessons to be drawn from the elevated rates of depreciation experienced by Japan during the 1990's, it is clearly important for the EU to quickly re-establish the conditions necessary to ensure a revival in investment spending. If this does not occur, it will be difficult for the EU to avoid the type of problems, including technological obsolescence, experienced by Japan during its "lost decade".*

CONCLUDING REMARKS

This paper has provided a detailed description of the current version of the Ecofin Council approved production function (PF) methodology. Compared with the previous 2006 paper, the single most important change outlined in the present 2010 text relates to the new TFP methodology. In this regard, section 2 has shown that the new KF methodology improves the measurement of trend TFP in real time by exploiting the information content from the capacity utilisation (CU) series. The CU series was clearly shown to be a good candidate for extracting the cyclical component of the actual TFP series and the resultant trend TFP estimates produced by the new KF method can be demonstrated to have a number of proven, & quantitatively important, advantages relative to the old HP filter approach.

Whilst the degree of uncertainty surrounding potential growth and output gap estimates will hopefully be reduced due to the introduction of the new KF inspired TFP methodology, it is clear that uncertainty has not been, and never will be, completely eliminated. Whilst every effort is being made to produce reliable, real time, output gap estimates, policy makers need to be reminded that there will never be a method which will remove the need for all revisions since uncertainty is an inherent part of the policymaking process. Consequently, potential growth and output gap revisions, due to, for example, forecast & data uncertainties, will inevitably remain a fact of life for policy makers to grapple with. In addition, distinguishing cyclical from structural factors in real time will continue to be prone to error, with a large element of judgement always being needed in assessing underlying potential output trends. In this respect the PF methodology can only ever be described as "work-in-progress" rather than a final product. We will always need to periodically fine-tune the method based on either the lessons learnt from individual country experiences; from evaluating the advantages / disadvantages of alternative specifications / estimation approaches; from exploiting / experimenting with new data sources; or from simply the need to keep the method consistent with developments in the literature.

Since the PF method is the reference to be used by the Commission services for calculating structural budget balances, it is clear that the pressure for changing particular aspects of the approach will continue to be intense over a medium to long term time horizon. It is important in this respect that any changes to the methodology are assessed on the basis of some fundamental operating principles, with the following being the most important ones used in establishing the method back in 2002 and which have inspired all subsequent modifications of the approach up until the present time :

- **SIMPLICITY** : whilst many academically more complex suggestions could be put forward for changing the present PF methodology, the simplicity of the approach, where the key inputs and outputs are clearly delineated, is something which should be retained in the future given the possible use of these figures in an operationally sensitive area such as structural budget balance calculations.

- **TRANSPARENCY / EQUAL TREATMENT FOR ALL MEMBER STATES** : This principle of transparency is closely linked with the first principle of simplicity, since individual Member States must be happy that any methodology which would be used for policy surveillance purposes is fully transparent and replicable as well as being as judgement free and automated as possible. In addition, it must be accepted that any changes to the methodology should only occur following an open and fair consultation process with all of the Member States. Furthermore, adjustments for individual country specificities should be kept to an absolute minimum in any future revisions, with equal treatment for all countries being a principle which should be assiduously respected.

- **<u>PRUDENCE</u>** : One of the guiding principles which was adhered to in drawing up the original and present versions of the PF method is the need to take a "prudent" view regarding changes to the methodology aimed at assessing the past and future evolution of potential growth in the EU. In this regard the cyclicality of the estimates produced is a very serious issue, with the ideal PF method being one which produces a potential growth series which is less cyclical than the commonly used HP filter method, with output gaps growing quickly in the downswing and closing rapidly in the upswing. In this regard while the differences in terms of cyclicality between the various methods may be small, nevertheless reducing the cyclicality of the PF estimates to an absolute minimum should be actively striven for in any future changes to the method. This cyclicality issue is particularly important in avoiding the generation of an excessively optimistic picture for potential growth, and by implication structural budget balance positions, in the upswing stage of the cycle. Consequently any future changes to the estimation methodology must be biased towards taking a prudent view.

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ANNEXES

Annex 1 : Detailed technical description of the new TFP methodology

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ANNEX 1 : DETAILED TECHNICAL DESCRIPTION OF THE NEW TFP METHODOLOGY

The model : For convenience, model (2.2) from section 2 of the main text is reproduced below, together with the dynamic specification of the unobserved components:

$$\text{(2.2)} \qquad \begin{aligned} tfp_t &= p_t + c_t \\ u_t &= \mu_U + \beta\, c_t + e_{Ut} \qquad \beta = \frac{1}{1-\alpha(1-\gamma)} > 1 \end{aligned}$$

where e_{Ut} is a random shock that may be correlated like in $e_{Ut} = \delta_U\, e_{Ut-1} + a_{Ut}$, with $V(a_{Ut}) = V_{Ut}$. The unobserved components dynamic is such that:

$$\text{(A2.1)} \qquad \begin{aligned} \Delta\, p_t &= \mu_{t-1} \\ \mu_t &= \omega(1-\rho) + \rho\, \mu_{t-1} + a_{\mu t} \qquad V(a_{\mu t}) = V_\mu \\ c_t &= 2A\cos(2\pi/\tau)\, c_{t-1} - A^2\, c_{t-2} + a_{ct} \qquad V(a_{ct}) = V_c \end{aligned}$$

Prior assumptions : In this annex, p(·) denotes a density, p(·|·) a conditional distribution, E(·) represents expected value and E(· | ·) a conditional expectation. Let θ denote the set of parameters, in model (2.2)-(A2.1), i.e. $\theta \equiv (A, \tau, V_c, \omega, \rho, V_\mu, \mu_U, \beta, \delta_U, V_U)$. For the prior distribution p(θ) we impose the independence structure:

$p(\theta) = p(A)\, p(\tau)\, p(V_c)\, p(\omega)\, p(\rho)\, p(V_\mu)\, p(\mu_U, \beta, \delta_U, V_U)$
with

$$\begin{aligned}
p(A) &= \text{Beta}(4.45, 6.10) \\
p\left(\frac{\tau-\tau_l}{\tau_u-\tau_l}\right) &= \text{Beta}(1.86, 4.97) \qquad \tau_l = 2 \text{ and } \tau_u = 25 \\
p(V_c) &= IG(s_{c0}, 6) \\
p(\omega) &= N(1.5 \cdot 10^{-2}, .005^2) \\
p(\rho) &\propto N(.80, .24^2) \times I_{(0,1)} \\
p(V_\mu) &= IG(s_{\mu 0}, 6) \\
p(\mu_U \mid V_U) &\propto N(.0, 1.7^2 \cdot V_U) \times I_{[-.1,.1]} \\
p(\delta_U \mid V_U) &\propto N(.0, 30^2 \cdot V_U) \times I_{(0,1)} \\
p(\beta \mid V_U) &\propto N(1.4, 50^2 \cdot V_U) \times I_{[0,5]} \\
p(V_U) &= IG(s_{U0}, 6)
\end{aligned}$$

where Beta (· , ·) is the Beta distribution, N(· , ·) is the Normal density, IG(· , ·) is the inverted Gamma distribution parameterized as in Bauwens et al. (1999, p.292), and I_S is an index set for imposing the support S. The mean cycle amplitude and periodicity are set a priori to 0.4 and 8.0, with standard deviation 0.2 and 3.5 respectively so as to not be excessively restrictive. Bounds equal to 2 and 25 are imposed to the periodicity parameter. The TFP annual growth is centred about a mean of 1.5%, with a standard deviation of 0.5 percentage point. We use a NIG structure for the capacity utilization parameters μ_U, β, δ_U, and V_U mainly for computational convenience. This assumption implies that the first three parameters have a marginal prior distribution of the Student type. For instance, the marginal prior for β is centred around a mean at 1.4 with standard deviation $50 \times E(V_U)^{1/2}$. We impose a positive support for β, expecting that the posterior accumulates mass on the 0-bound in the case negative values better fit the data. The AR(1) specification with parameter δ_U serves for Belgium, France, the Netherlands and the UK. For variance parameters, IG distributions are used, with 6 degrees of freedom so as to set the mean and standard deviations equal a priori. As a "tuning" by country was needed, we report in Table A2.1 the prior means for the variance parameters. With 6 degrees of freedom in the IG-distribution above, the hyperparameters s_{c0}, $s_{\mu 0}$, and s_{U0} can be recovered as four times the prior mean (see Bauwens et al., 1999, p.292)[56].

Table A2.1 : Mean and standard deviation of IG-variance priors

	BE	DE	DK	EL	ES	FR	IE	IT	LU	NL	PT	UK
$V_c\,(\times 10^{-4})$	1.6	1.6	1.6	1.7	2.0	1.6	14	1.6	3.8	2.6	2.4	1.6
$V_\mu(\times 10^{-6})$	2.4	2.4	22	20	1.2	8.0	40	2.0	20	1.0	20	10
$V_U(\times 10^{-4})$	4.8	16.3	9.3	2.8	3.1	3.6	12.8	1.8	6.4	1.8	9.3	5.1

Source: Commission services

As can be seen, emphasis is put on a smooth trend: the expected value of the cycle shock variance V_c is set to about 10 to 100 times greater than that of the slope shocks V_μ.

From prior to posterior : Given these prior assumptions, the objective is to find the joint posterior distribution of the TFP trend and cycle and of the parameters conditionally on the data, i.e. $p(c^T, p^T, \theta | Y^T)$ where $x^T \equiv (x_1,\ldots,x^T\}$ and $Y^T \equiv (TFP^T, U^T)$. Given model (2.2), no closed form expression for this posterior is available but "draws" from $p(c^T,p^T, \theta | Y^T)$ can be obtained using a Gibbs sampling scheme. The full conditionals of interest are:

- $p(c^T,p^T |\theta, Y^T)$ and
- $p(\theta | c^T, p^T, Y^T)$

We first focus on simulating the unobserved components conditionally on model parameters. It is useful to cast equations (2.2)-(A2.1) into a state space format such that:

$$Y_t = H\,\xi_t$$
$$\xi_{t+1} = D + F\,\xi_t + w_{t+1},$$

where Y_t is the vector of observations, $\xi_t = (p_t, \mu_t, c_t, c_{t-1}, e_{Ut})'$ is the state vector, $w_t = (0, a_{\mu t}, a_{ct}, 0, a_{Ut})'$ is a Gaussian error vector with zero mean and singular variance matrix Q. The time-invariant matrices H, D, F and Q can be straightforwardly recovered. For instance H contains the vector (1,0,1,0,0) on the first row and $(0,0,\beta,0,1)$ on the second one. As usual, $\xi_{t|k}$ and $P_{t|k}$ denote the conditional expectation $E(\xi_t | \theta, Y^k)$ and variance $V(\xi_t | \theta, Y^k)$. Samples from $p(c^T,p^T |\theta, Y^T)$ will be obtained through $p(\xi^T |\theta, Y^T)$. Use is made of the Carter and Kohn (1994) state sampler defined by the identity:

$$p(\xi^T| \theta, Y^T) = p(\xi_T| \theta, Y_T)\,\Pi_{t=1,\ldots,T-1}\, p(\xi_t| \theta, Y^t, \xi_{t+1})$$

A draw from $p(\xi^T |\theta, Y^T)$ can be obtained as follows:

i. compute $\xi_{t|t}$, and $P_{t|t}$, t=2,…,T, via the diffuse Kalman filter (de Jong, 1991);
ii. given $\xi_{T|T}$, and $P_{T|T}$, sample ξ_T from $p(\xi_T| \theta, Y_T)=N(\xi_{T|T}, P_{T|T})$;

[56] The expected value of a random variable distributed as $x \sim IG(s,v)$ is $E(x)=s/(v-2)$.

iii. for t=T-1 to t=2, sample backward ξ_t from $p(\xi_t| \theta, Y_{t,} \xi_{t+1}) = N(E[\xi_t| \theta, Y^t_, \xi_{t+1}], V[\xi_t| \theta, Y^t_, \xi_{t+1}])$.

Steps (i) and (ii) only involve standard results. If TFP has two more observations than capacity utilization at the sample end, then the filter is run on these two points with H reduced to its first row, the second series being treated as missing. Step (iii) needs the conditional moments $E[\xi_t| \theta, Y^t_, \xi_{t+1}]$ and $V[\xi_t| \theta, Y^t_, \xi_{t+1}]$. From the joint distribution of ξ_t and ξ_{t+1} conditional on θ, Y^t, we get:

$$E[\xi_t| \theta, Y^t, \xi_{t+1}] = \xi_{t|t} + P_{t|t} F' (P_{t+1|t})^{-1} (\xi_{t+1} - F \xi_{t|t})$$
$$V[\xi_t| \theta, Y^t, \xi_{t+1}] = P_{t|t} - P_{t|t} F' (P_{t+1|t})^{-1} F P_{t|t}$$

Because of the model structure, not all elements of the state need to be simulated. From (2.2)-(A2.1), given Y_t knowledge of c_t determines both p_t and e_{Ut}. Hence for launching the algorithm, both c_T and c_{T-1} need to be sampled after which c_{t-1} is the only element to simulate. Since model (A2.1) does not have shocks on the trend level, c_{t-1} also determines μ_{t-1}. Still for our model specification, the algorithm can stop at t=2 since p_1, c_1, μ_1 and e_{U1} will be available.

We now turn to the second full conditional distribution, $p(\theta| c^T, p^T, Y^T)$. Several routes are possible: our strategy exploits model parameterization, prior block-independence and likelihood factorization in order to build three parameter blocks. Indeed the model structure implies that the density $p(c^T, p^T, Y^T| \theta)$ can be factorized as:

$$p(c^T, p^T, Y^T| \theta) = p(c^T|A,\tau,V_c)\, p(p^T| \omega, \rho, V_\mu)\, p(U^T| c^T , \mu_U, \beta, \delta_U, V_U)$$

Then the block-independence prior assumption makes the full conditional $p(\theta| c^T, p^T, Y^T)$ verifying:

$$p(\theta| c^T, p^T, Y^T) = p(A,\tau,V_c| c^T)\, p(\omega, \rho, V_\mu| p^T)\, p(\mu_U, \beta, \delta_U, V_U| c^T, U^T)$$

We first consider the conditional distribution $p(\omega, \rho, V_\mu| p^T)$. A single-move Gibbs scheme is used, so each parameter is sampled given the other two and the trend. Let ω_0 and $V_{\omega 0}$ denote prior mean and variance of the ω-prior distribution. The Normal prior assumption implies:

$p(\omega| \rho, V_\mu, p^T) = N(\omega_*, V_{\omega*})$ with

$$V_{\omega*} = \left[\frac{(T-2)(1-\rho)^2 + 1 - \rho^2}{V_\mu} + \frac{1}{V_{\omega 0}} \right]^{-1} \qquad \text{and}$$
$$\omega_* = V_{\omega*} \left[\frac{(1-\rho)\sum_{t=3}^{T}\left(\Delta p_t - \rho \Delta p_{t-1}\right) + (1-\rho^2)\Delta p_2}{V_\mu} + \frac{\omega_0}{V_{\omega 0}} \right]$$

For the autoregressive parameter, we have:

$$p(\rho \mid \omega, V_\mu, p^T) \propto p(p^T \mid \rho, \omega, V_\mu)\, p(\rho)$$
$$\propto p(\Delta p_2 \mid \rho, \omega, V_\mu) \prod_{t=3,\dots,T} p(\Delta p_t \mid p^{t-1} \rho, \omega, V_\mu)\, p(\rho)$$

Let ρ_0 and $V_{\rho 0}$ denote prior mean and variance of the ρ-prior distribution, i.e.

$p(\rho) \propto N(\rho_0, V_{\rho 0}) \times I_{(0,1)}$. The first term of the equation above verifies:

$$p(\Delta p_2 \mid \rho, \omega, V_\mu) \propto \exp(\rho^2 (\Delta p_2 - \omega)^2 / (2V_\mu))$$

while the product of the last two terms is such that:

$$\Pi_{t=3,\ldots,T}\, p(\Delta p_t \mid p^{t-1} \rho, \omega, V_\mu)\, p(\rho) \propto N(\rho_*, V_{\rho *}) \times I_{(0,1)}$$

with

$$V_{\rho *} = \left[\frac{\sum_{t=3}^{T} (\Delta p_{t-1} - \omega)^2}{V_\mu} + \frac{1}{V_{\rho 0}} \right]^{-1}$$

$$\rho_* = V_{\rho *} \left[\frac{\sum_{t=3}^{T} (\Delta p_t - \omega)(\Delta p_{t-1} - \omega)}{V_\mu} + \frac{\rho_0}{V_{\rho 0}} \right]$$

Hence, "draws" from the full conditional $p(\rho \mid \omega, V_\mu, p^T)$ can be obtained for instance via a Metropolis-Hastings scheme with proposal $q(\rho) = N(\rho_*, V_{\rho *}) \times I_{(0,1)}$ as above with acceptance probability:

$$\alpha = \min\left(1, \frac{p(\Delta p_2 \mid \rho', \omega, V_\mu)}{p(\Delta p_2 \mid \rho, \omega, V_\mu)} \right)$$

where ρ' is the candidate draw from $q(\rho)$.

For the slope shock variance V_μ, the full conditional $p(V_\mu \mid \rho, \omega, , p^T)$ verifies:

$$p(V_\mu \mid \rho, \omega, , p^T) = IG(s_{\mu *}, \nu_{\mu *})$$

with

$$s_{\mu *} = s_{\mu 0} + (1 - \rho^2)(\Delta p_2 - \omega)^2 + \sum_{t=3}^{T} (\Delta p_t - \Delta p_{t-1} - \omega(1 - \rho))^2$$

$$\nu_{\mu *} = \nu_{\mu 0} + T - 1$$

where $\nu_{\mu 0} = 6$ is the number of degrees of freedom of the V_μ -prior distribution.

Focusing next on $p(A, \tau, V_c \mid c^T)$, we consider the full conditionals $p(A \mid \tau, V_c, c^T)$, $p(\tau \mid A, V_c, c^T)$ and $p(V_c \mid A, \tau, c^T)$. The first two verify:

$$p(A \mid \tau, V_c, c^T) \propto p(c_1, c_2 \mid A, \tau, V_c)\, \Pi_{t=3,\ldots,T}\, p(c_t \mid c^{t-1}, A, \tau, V_c)\, p(A)$$

and

$$p(\tau \mid A, V_c, c^T) \propto p(c_1, c_2 \mid A, \tau, V_c)\, \Pi_{t=3,\ldots,T}\, p(c_t \mid c^{t-1}, A, \tau, V_c)\, p(\tau)$$

Sampling directly from these conditionals is not possible but both densities are straightforward to evaluate. Program GAP uses the adaptive rejection Metropolis scheme (ARMS) proposed by Gilks et al. (1995, 1997); a Metropolis-Hastings step is a possible alternative. For the distribution $p(V_c \mid A, \tau, c^T)$, the IG-conjugate framework implies (see Bauwens, Lubrano and Richard, 1999, p.304):

$$p(V_c \,|A, \tau, c^T) = IG(s_{c*}, \nu_{c*})$$

with:

$$s_{c*} = s_{c0} + (c_1 \;\; c_2)\, \Sigma_c^{-1}\, (c_1 \;\; c_2)' + \Sigma_{t=3,\ldots,T}\; a_{ct}^2$$
$$\nu_{c*} = \nu_{c0} + T$$

where ν_{c0}=6 represents the degrees of freedom of the V_c-prior distribution, Σ_c is the variance-covariance matrix of $(c_1 \;\; c_2)$ given A and τ re-scaled by the innovation variance V_c, i.e. $\Sigma_c = V[(c_1 \;\; c_2)|A, \tau, V_c]/V_c$.

It remains to sample from the full conditional distribution $p(\mu_U, \beta, \delta_U, V_U| \, c^T, U^T)$. When the AR(1)-coefficient δ_U is present, a further Gibbs step is implemented to sample from $p(\mu_U, \beta, V_U| \, \delta_U, c^T, U^T)$ and $p(\delta_U \mid \mu_U, \beta, V_U, c^T, U^T)$. This last is similar to sampling the trend AR(1)-coefficient ρ, so focus is put on $p(\mu_U, \beta, V_U| \, \delta_U, c^T, U^T)$ and we assume δ_U=0 for simplifying exposition. It is convenient to re-write the prior for μ_U, β as in:

$$p(\mu_U, \beta| \, V_U) = N(m_{U0}, V_U \cdot M_U^{-1})$$

where M_U is the precision matrix associated to the prior specification for μ_U and β. Let $Z_t \equiv (1 \;\; c_t)$ represent the regressors in (2.2), Z be the T×2 matrix of regressors, and U the T×1 vector of endogenous variables, $U \equiv U^T$. Standard results from the NIG-conjugate framework yield:

$$p(\mu_U, \beta, V_U| \, \delta_U, c^T, U^T) = NIG(m_{U*}, s_{U*}, M_{U*}, \nu_{U*})$$

with

$$M_{U*} = M_{U0} + Z'Z$$
$$m_{U*} = M_{U*}^{-1}\, [M_{U0}\, m_{U0} + Z'U]$$
$$s_{U*} = s_{U0} + \Sigma_{t=1,\ldots,T}\; a_{Ut}^2$$
$$\nu_{U*} = \nu_{U0} + T$$

where ν_{U0} = 6 is the number of degrees of freedom of the V_U-prior distribution.

This closes the circle of simulations. Markov chains properties discussed in Tierney (1994) insure convergence to the joint posterior $p(c^T, p^T, \theta|Y^T)$. To check convergence, GAP uses the Geweke's statistic to test whether the first 50% and the last 20% draws of the chain have the same mean (see Geweke, 1992). For model (2.2) and the data we have considered, increasing the burn-in period was generally enough to overcome convergence problems. Once convergence is confirmed, posterior distributions of any quantity of interest as well as posterior moments can be easily obtained – GAP shows the posterior distributions of a broad selection of variables including parameters and unobserved components. A further model check via Box-plot of residuals autocorrelations is offered. More information can be found in the GAP site. Readers interested in further details about simulations or in model extensions are referred to Planas, Rossi and Fiorentini (2008).

ANNEX 2 : DETAILED TECHNICAL DESCRIPTION OF THE NAWRU METHODOLOGY

2.1 : NAWRU METHODOLOGY FOR THE "OLD" MEMBER STATES : This part of annex 2 discusses various issues related to the Kalman Filter based NAWRU estimation methodology. First of all, it provides a description of the theoretical framework underlying the NAWRU estimates. It starts from a standard model of the labour market, with explicitly formulated wage and labour demand equations. In particular it is shown how the Phillips curve, which links the change in wage inflation to the unemployment gap, is shifted by observed and unobserved shocks to the wage rule and the labour demand equation. Within this context the concept of structural unemployment or NAWRU can be discussed more clearly. This derivation also allows one to provide an economic interpretation for differences between the Euro Area and US labour markets.

2.1.1. The Labour Market Model : Following standard textbooks, there are broadly four different hypotheses which try to describe the labour market: the neoclassical view, the efficiency wage approach, the wage bargaining theory and the search model. A generic wage rule covering all four hypothesis can be formulated as follows.

$$w_t - p_t^e = a_0 + (1-\mu)b_t^e + \mu pr_t^e - \beta u_t + a_t^w \qquad (1)$$

Workers / trade unions negotiate a nominal wage w_t at time t conditional on the price expectation p_t^e, on the expected level of the reservation wage b_t, on expected productivity $pr_t = y_t - l_t$[57] and on the unemployment rate u_t. The term a_t^w is a shock to the wage-setting rule that can be autocorrelated. As shown by Pissarides (1999), the four macroeconomic theories imply certain restrictions on the parameter values of equation (1): both the neoclassical and the efficiency wage models imply $\mu = 0$, i.e. wages are not directly linked to productivity. The wage bargaining and the search model allow instead for productivity to play a role. Within this latter class of models, the magnitude of productivity indexation depends crucially on the bargaining strength of workers. In an atomistic labour market without any market power for workers such as in the neoclassical model, wages would be equal to the reservation wage. By contrast, in a highly unionised labour market, μ would approach unity.

Theories also differ in the specification of the reservation wage. In the neoclassical model the reservation wage would be the value of leisure, a concept derived from a utility function for workers which is defined in terms of consumption and leisure. Consequently, in the neoclassical model, consumption and leisure time would be the arguments of b_t. While the value of leisure could also play a role under the other hypotheses, these generally stress a non-market wage as an alternative. The non-market wage could be for instance unemployment benefits, the value of home production or the income earned in the shadow economy.

Another important element is the concept of productivity entering the wage equation, namely either average labour productivity or "marginal productivity[58]". Under the neoclassical model, the search and efficiency wage hypothesis, the relevant concept seems to be "marginal productivity" while in bargaining models an average productivity concept applies. As will be

[57] The notion of productivity entering the wage equation will be discussed in more detail later.
[58] Marginal productivity and the demand wage for labour are used interchangeably. The term marginal productivity is not entirely correct. Marginal productivity corrected for the mark-up of prices over marginal cost would be the correct expression.

shown below in situations where average and marginal productivity diverge, the two productivity concepts have implications for the structural unemployment rate and also for the short run adjustment of wages. The wage rule expressed in eq (1) is very similar to the rule formulated by Blanchard and Katz (1999). Here two generalisations are introduced. First, it is assumed that expectations not only have to be formulated about prices but also about the reservation wage and productivity and we allow for slightly more general expectation formation schemes. The second generalisation concerns the concept of productivity which enters the wage rule. We will explicitly distinguish between the average and marginal product of labour.

In order to close the model, labour demand must be specified. It is assumed that firms set labour demand at its profit maximising level by equating the marginal revenue product of labour to the real wage. The resulting first order condition of the optimisation problem is given by equation (2).

$$w_t - p_t = (y_t - l_t) + x_t \qquad (2)$$

It can be interpreted in two directions. Starting from the right hand side, eq. (2) determines the "demand wage for labour", which is the wage the firm is willing to pay for a given level of marginal productivity. Alternatively, for given real wages, it determines the marginal product of labour the firm is aiming for. Note that marginal and average productivity are not always proportional. The term x can drive a wedge between marginal and average productivity. One can think of the variable x as a shock to a (long run) labour demand equation (as implied by the underlying Cobb Douglas production function) by simply rewriting (2) as

$$l_t = y_t - (w_t - p_t) + x_t \; . \qquad (2')$$

The variable x can itself be a function of various factors and it is useful to distinguish between a structural (x*) and a cyclical / transitory component (ρ)

$$x_t = x_t^* + \rho_t \, . \qquad (3)$$

After having determined the demand wage of firms, one can address the issue of which productivity concept is used by workers in their wage schedule. In particular, do they take into account shocks to labour demand when setting wages ? We are not imposing an a priori restriction about the concept of productivity used by workers in setting wages and define the concept of productivity entering the wage rule as

$$pr_t = (y_t - l_t) + \psi x_t, \quad 0 \leq \psi \leq 1 \, . \qquad (4)$$

We also express the reservation wage as a fraction of a combination of productivity and x,

$$b_t = b_t^0 + (y_t - l_t) + \psi x_t \qquad (5)$$

where b_t^0 is the logarithm of the replacement rate. Note that as b_t^0 is allowed to vary over time, equation (5) is not restricting the dynamics of the reservation wage.

***Adjustment of wages to inflation and productivity**:* The adjustment of wages to economic conditions can be delayed because of limited information in the formation of expectations or because of institutional rigidities (e.g. a fixed contract length). With the annual data used here, we try to capture two extremes. Either instantaneous adjustment of wages to both inflation and productivity, i.e. adjustment within the same period (one year) or completely backward looking behaviour where wages only respond with a lag of one year. Such an extreme case could occur for example if wage contracts were negotiated at the beginning of each year; with a duration of one year, and where workers / trade unions would simply extrapolate inflation or productivity trends from the previous year. Any parameter setting between these two extremes is of course possible and is determined by the coefficients a and c in the following expectation formulas :

$$\pi_t^e = a\pi_t + (1-a)\pi_{t-1} \tag{6a}$$

$$\Delta pr_t^e = c\Delta pr_t + (1-c)\Delta pr_{t-1}. \tag{7a}$$

The degree of nominal rigidity is proportional to (1-a) while the degree of real rigidity is proportional to (1-c). However, for some countries the unemployment gap appears in the Phillips curve as a quasi difference. This cannot be generated with the moving average scheme, therefore we also allow for adaptive expectations schemes of the following form :

$$\pi_t^e = a\pi_{t-1} + (1-a)\pi_{t-1}^e \tag{6b}$$

$$\Delta pr_t^e = c\Delta pr_{t-1} + (1-c)\Delta pr_{t-1}^e. \tag{7b}$$

We also allow for combinations between (6,7a) and (6,7b) in the regressions. Equations (1) to (7) determine the structural unemployment rate which is defined as the level of unemployment when there are no expectation errors, i.e. $\mathrm{p}_\mathrm{t}^\mathrm{e} = \mathrm{p}_\mathrm{t}$, $pr_t^e = pr_t$ and where the wage share is equal to its long run level, i.e. $x_t = x_t^*$. Under these conditions, the equilibrium unemployment rate is given by

$$u_t^* = [a_0 + (1-\mu)b_t^0 + (\psi-1)x_t^*]/\beta \tag{8}$$

Equation (8) shows that the equilibrium level of unemployment depends positively on the reservation wage (which itself is a function of labour taxation, unemployment replacement rate etc.), and negatively on the trend value of the labour demand shock, if workers do not completely take into account x*. This sounds intuitively plausible. Imagine, for example, an increase in the average training costs for workers. This obviously is a cost component for firms related to individual workers. In determining labour input, the firm must take these costs into account. If wages do not respond to an increase in training costs then effective labour costs increase and firms respond with a decline in labour demand. If the increase in training costs is permanent then the equilibrium level of unemployment will be higher. If training costs are borne by workers in the form of lower wages ($\psi = 1$), equilibrium unemployment will not be affected.

A relationship between the change in nominal wage inflation and the unemployment gap can be derived, with shocks to labour productivity, labour demand and the terms of trade as additional explanatory variables:

$$\Delta^2 w_t = \phi^{pr} \Delta^2 (y_t - l_t) + \phi^{ws} \Delta^2 ws_t + \phi^{tot} \Delta^2 tot_t - \beta(u_t - nairu_t) + v_t^w \quad (9)$$

where the reduced form coefficients of the Phillips curve linked to the structural coefficients are the following :

$$\phi^{pr} = \frac{(c-a)}{(1-a)}$$

$$\phi^{ws} = \frac{(c-a)+(\psi-1)(c-1)}{(1-a)}$$

$$\phi^{tot} \geq 0 .$$

The error term v_t^w is a function of a_t^w, ρ_{t-i} and Δx_{t-1}^*.

The Phillips curve shows the short run response of nominal wages to labour productivity, labour demand shocks and the unemployment gap. The response to the unemployment gap is intuitively plausible. Whenever unemployment is above the NAIRU, nominal wage growth will decelerate and vice versa. However, this link is not perfect but is disturbed by observed and unobserved shocks to the wage rule and the labour demand equation. How nominal wage growth responds to productivity and labour demand shocks (here approximated by changes in the growth rate of the wage share) depends on a variety of factors.

Short run nominal wage response to productivity shocks*:* Nominal wages respond to a shock in productivity via two channels, a productivity channel and an inflation channel. The strength of the response depends on how strongly inflation and productivity expectations respond to the productivity shock within the first year. Everything else equal, wages respond positively to productivity (with an elasticity of c) but they respond negatively to the extent that productivity affects inflation (with an elasticity equal to –a). Whether the response is positive or negative actually depends on the relative magnitude of c and a.

Short run response of nominal wages to changes in labour demand shocks: A similar consideration applies to labour demand shocks. The wage rule implies that wages respond positively to labour demand shocks (to the extent they are taken into account by workers (namely by the size of ψ)). The difference compared to the productivity response comes from the parameter ψ. If wages only respond to productivity but not to the demand wage for labour ($\psi = 0$) then there will be no positive transmission of a labour demand shock. Turning to the other extreme case, with wages responding fully to the labour demand shock, then the elasticity of wages w. r. t. labour demand shocks will be equal to the productivity response of wages. However, in general, the magnitude of the positive response of wages to labour demand shocks will be smaller compared to labour productivity shocks. Also notice from the inflation rule that labour demand shocks have a negative effect on inflation. Therefore to the extent wages respond to current inflation (negatively), they also respond negatively to labour demand shocks via the inflation channel.

Short run response of nominal wages to terms of trade (TOT) shocks : The theoretical derivation of the wage equation was done in a closed economy context. Obviously open economy aspects are likely to play a role in wage setting, especially if there is a divergence between domestic and import prices and if wages are linked to the consumer price deflator. To the extent that these conditions are fulfilled, one would also expect that nominal wages respond positively to the wedge between consumer price, and GDP, inflation. In order to capture this open economy aspect, a TOT variable is added to the Phillips curve.

2.1.2. Comparing the Euro Area and the US Phillips Curves : The Phillips curve estimates for the Euro Area and the US reported earlier in Table 3.1 show similarities in terms of both the size and the significance of the parameter estimates. In both cases the coefficient on the unemployment gap is highly significant. However, the response of nominal wages to the unemployment gap is somewhat stronger in the Euro Area than in the US, suggesting a higher sensitivity of nominal wage growth to unemployment fluctuations.

There is also evidence of a positive short run response of nominal wages to labour productivity growth, lending support to theories such as the wage bargaining and the search models. The elasticity within a year is 0.18 in the Euro Area and 0.29 in the US. This suggests that the productivity response by far exceeds the inflation response. This seems plausible. First of all, central banks tend to accommodate productivity shocks and keep inflation stable. Therefore productivity shocks can lead to higher real wage growth via nominal wage growth. Moreover, we are looking at wages per employee and changes in hours are consequently translated directly into changes in wages. In addition, to the extent that workers receive "piece rate" wages, the translation of productivity into changes in wages is direct. Finally, to the extent that wages are negotiated at the sectoral or even the firm level, information about local productivity might be more easily available than information about aggregate inflation.

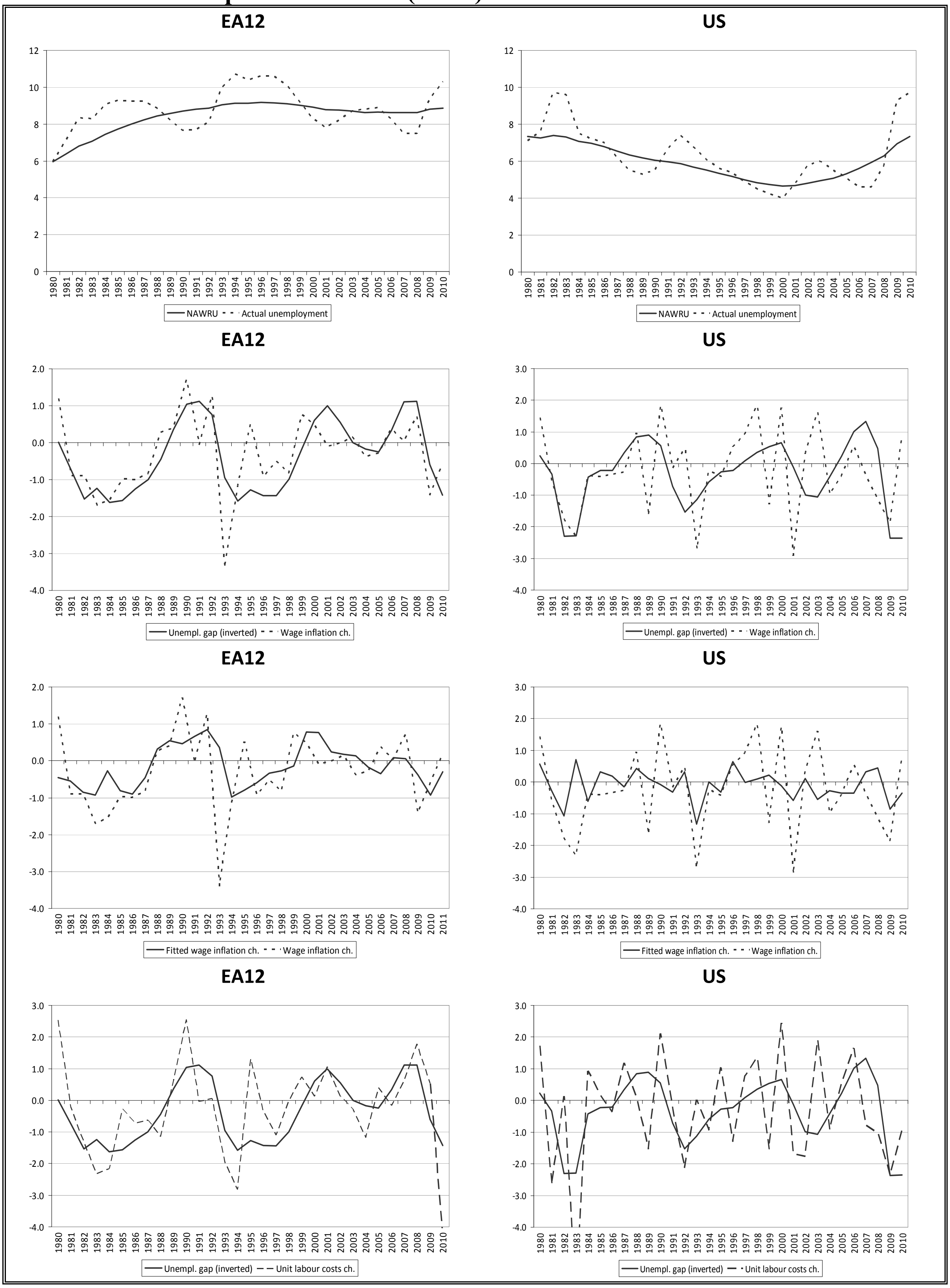
The empirical fit of the model can be assessed by comparing fluctuations in the (inverse of the) unemployment gap with fluctuations in wage indicators. The Phillips curve predicts that episodes in which the NAIRU is above the actual unemployment rate should be associated with an acceleration in wage inflation (see graph 1). Table 1 provides correlations between the unemployment gap as identified by our methodology and two alternative wage concepts, nominal wage inflation and unit labour costs. Both concepts of wage inflation are correlated with the (inverse) of the unemployment gap for the two regions. However, in the US, unit labour costs appear to be more strongly correlated to the unemployment gap than nominal wage inflation.

Table 1: Correlation between unemployment gap and wage indicators

	Euro Area	**US**
Δ^2 (Wage)	0.50	0.33
Δ^2 (ULC)	0.51	0.56

Source: Commission services

Graph 1: Euro Area (EA12) and US NAWRU estimations



Source: Commission services

Graph 1 illustrates the evolution of the NAWRU in the Euro Area and in the US as well as the fit of the Phillips curve. The two graphs on the top of the page show the NAWRU for the Euro Area and the US as estimated with our model. Euro Area structural unemployment peaked in the mid 1990s and has been slightly declining since until the outbreak of the financial crisis, when it reached levels above those observed in the 1990s. The US NAIRU has been on a steady decline since the early 1980s and started increasing again during the 2000s. The two graphs in the middle show how the (inverse) of the unemployment gap is correlated with the change in wage inflation. While there is a strong relationship, the Phillips curve specification suggests that other factors also influence the change in wage inflation. Finally, the two graphs at the bottom of the page illustrate the relationship between the unemployment gap and unit labour costs.

2.2 NAWRU Methodology for the "New" Member States : For calculating the NAWRU for the new Member States, a methodology proposed by the OECD is used (i.e. the "Elmeskov" method[59]). A simple model of the labour market predicts that expected real wages will rise whenever the unemployment rate is below the NAWRU and vice versa.

$$\Delta w_t - \pi_t^e = -\beta(u_t - nairu) + u_t^w \qquad (1a)$$

Assuming static inflation expectations

$$\pi_t^e = \pi_{t-1} = \Delta w_{t-1} \qquad (2)$$

gives the following Phillips curve relationship

$$\Delta^2 w_t = -\beta(u_t - nairu) + u_t^w \qquad (1b)$$

This is the most simple formulation of the Phillips curve which ignores all other possible influences on wage setting such as productivity, for example. Allowing for productivity shocks may be important for at least two reasons. Firstly, the new Member States show relatively high growth rates of productivity, thus productivity growth may be an important factor for wage growth. Secondly, for the EU15 member states we control for productivity shocks as well. The following paragraphs therefore present a simple extension of the framework presented above.

The wage rule (following the specification that we use for the EU15 member states) is given by :

$$w_t - p_t^e = (y_t - l_t) - \beta(u_t - nairu) + u_t^w \qquad (3a)$$

This can be rewritten as :

$$\Delta w_t - \pi_t^e = (y_t - l_t) - (w_{t-1} - p_{t-1}) - \beta(u_t - nairu) + u_t^w \qquad (3b)$$

Labour demand can be formulated as follows :

[59] J. Elmeskov (1993)

$$w_t - p_t = (y_t - l_t) + u_t^l \quad (4)$$

With static inflation expectations we obtain :

$$\pi_t^e = \pi_{t-1} = \Delta w_{t-1} - (\Delta y_{t-1} - \Delta l_{t-1}) .$$

Using this expectation rule, together with the labour demand schedule, one can reformulate the wage equation as follows :

$$\Delta^2 w_t = (\Delta^2 y_t - \Delta^2 l_t) - \beta(u_t - nairu) + u_t^w - u_{t-1}^l \quad (3c)$$

or

$$\Delta^2 ulc = \Delta^2 w_t - (\Delta^2 y_t - \Delta^2 l_t) = -\beta(u_t - nairu) + u_t^w - u_{t-1}^l \quad (3d)$$

This formulation indicates that unemployment is below the NAWRU whenever the growth rate of unit labour costs increases.

Given these alternative expressions (1b) and (3d), the calculation of the NAWRU proceeds in the following steps. Notice that both the β coefficient and the NAWRU series are unknown.

STEP 1 : Assuming the NAWRU to be constant and further assuming that the shocks have a mean of zero, one can calculate β by taking a first derivative (in discrete time) of eq. (1b) and (3d) with respect to the unemployment rate :

$$\beta_{ULC} = -\frac{\Delta^3 ulc}{\Delta u} \quad \text{and} \quad \beta_W = -\frac{\Delta^3 w}{\Delta u} \quad (4)$$

STEP 2 : With these estimates we can solve eq. (1b) and (3d) for the NAWRU (plus shock)

$$nairu_t = u_t + \frac{\Delta^2 w_t}{\beta_W} \quad \text{or} \quad nairu_t = u_t + \frac{\Delta^2 ulc_t}{\beta_{ULC}} \quad (5)$$

STEP 3 : Now one can use the right hand sides of eq. (5) to calculate the NAWRU by noticing that the right hand side is equal to the NAWRU and the shocks to the wage setting and labour demand equations. These shocks are eliminated by applying a filter to the right hand side. Notice, this procedure becomes arbitrarily close to applying a filter to the unemployment rate directly for large enough β .

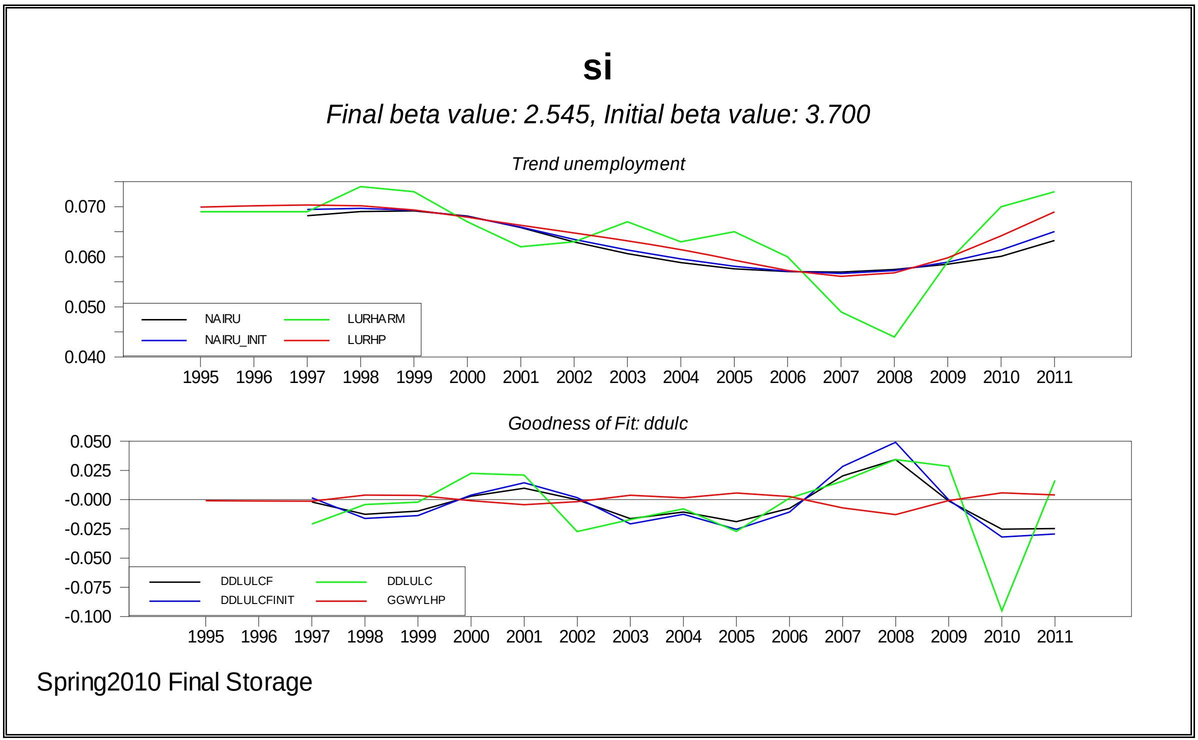
An alternative way, more computer-intensive, of obtaining the coefficient would be to make a search for the value that would best fit the observed changes in the growth rate of unit labour costs[60].

[60] Or of wages, but given initial results and theoretical considerations, the preference is given to unit labour costs.

Using an initial value for β (possibly obtained via the above 3-steps methodology), equation (5) is used to get the fitted $\Delta^2 ulc$, conditional to the value of β (and NAWRU). The fitted values can then be compared to the observed values of $\Delta^2 ulc$. Other possible values of the coefficient can then be tried. Practically, the procedure uses a grid search in the vicinity of the previous estimate of the coefficient, reiterated until convergence is reached. The current penalty function used to determine the best estimate leads to the minimisation of the sum of the absolute differences between the observed unit labour costs and the fitted unit labour costs.[61]

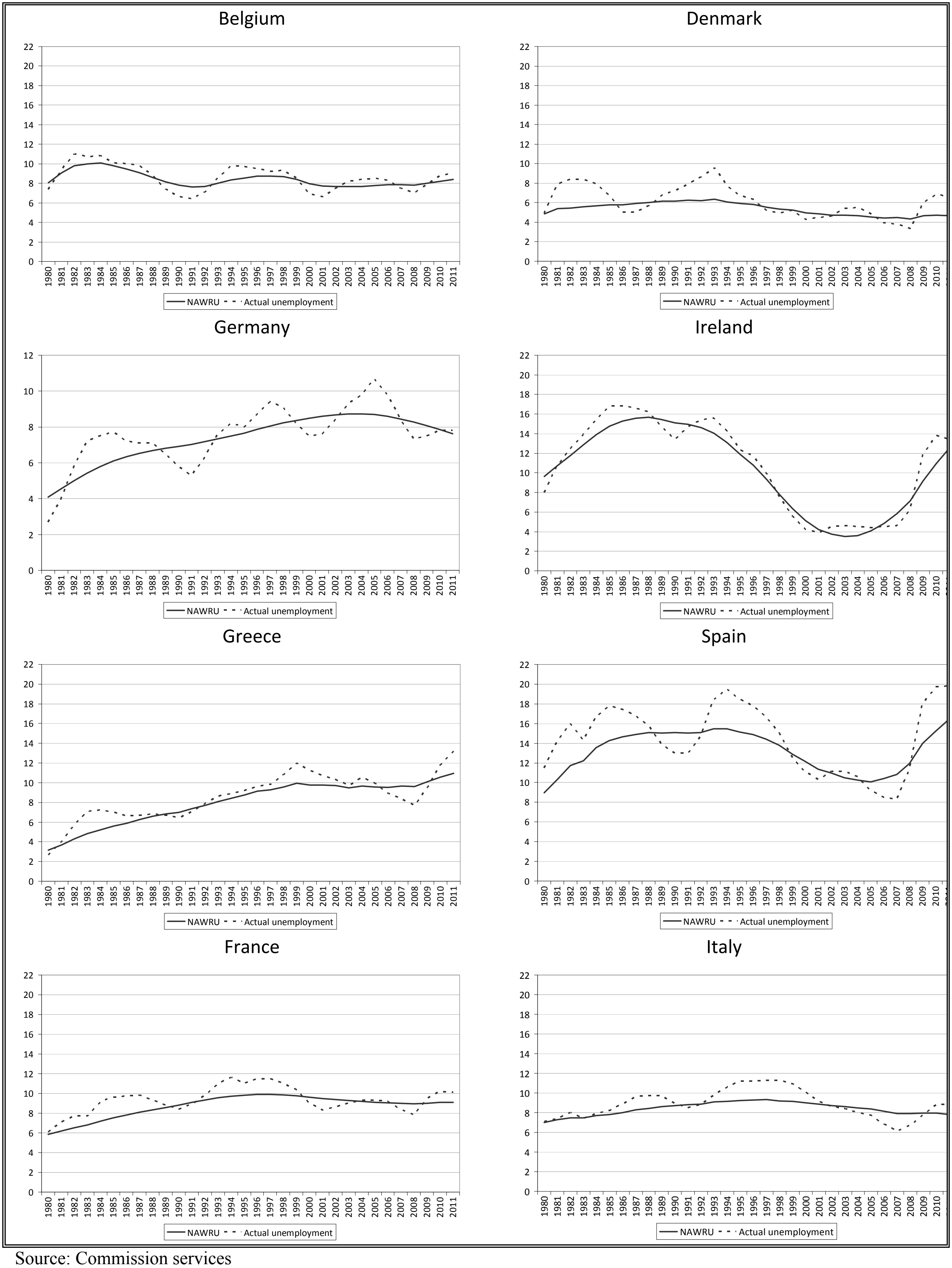
Starting in 2007, and in a comparable manner to that of the EU15 countries (where the complete model is re-estimated each time that a different information set is used), the β coefficient is evaluated in this way at the beginning of each new forecasting exercise. However, and to avoid too much instability or minor / trivial changes due to periodic modifications of the data set, the latest best estimate is only used after a comparison analysis combined with a visual inspection.

Graphs showing the application of this procedure to Slovenian data are given below. The first graph compares three alternative estimates of the NAWRU to the unemployment rate. The first estimate is obtained through the application of an HP filter to the unemployment rate series. The second and third estimates are based on the methodology described above, for different values of the β coefficient. The higher the value of β, the closer the NAWRU estimate gets to the HP-filter estimate. The second graph compares the changes in the growth rate of unit labour costs conditional to the estimated model, with the observed pattern of the unit labour costs. The procedure is designed to minimise this difference between the fitted and observed values.

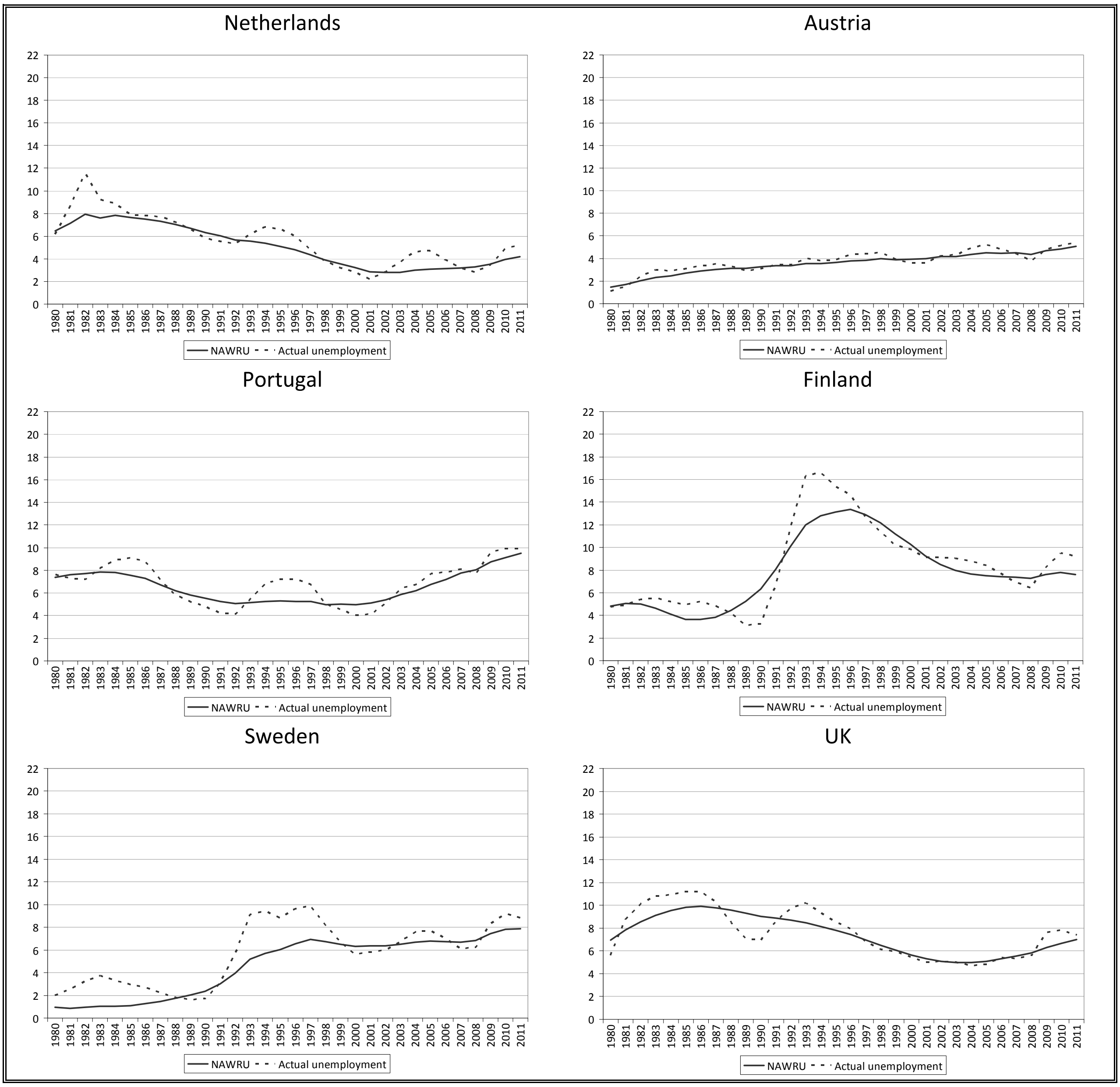


[61] This sum is calculated starting in 2001 in order to limit the transition effects and since the focus is naturally on the more recent period. However, the complete time series is always used for estimating the NAWRU.

Graph 2: EU's "Old" Member States - NAWRU estimates

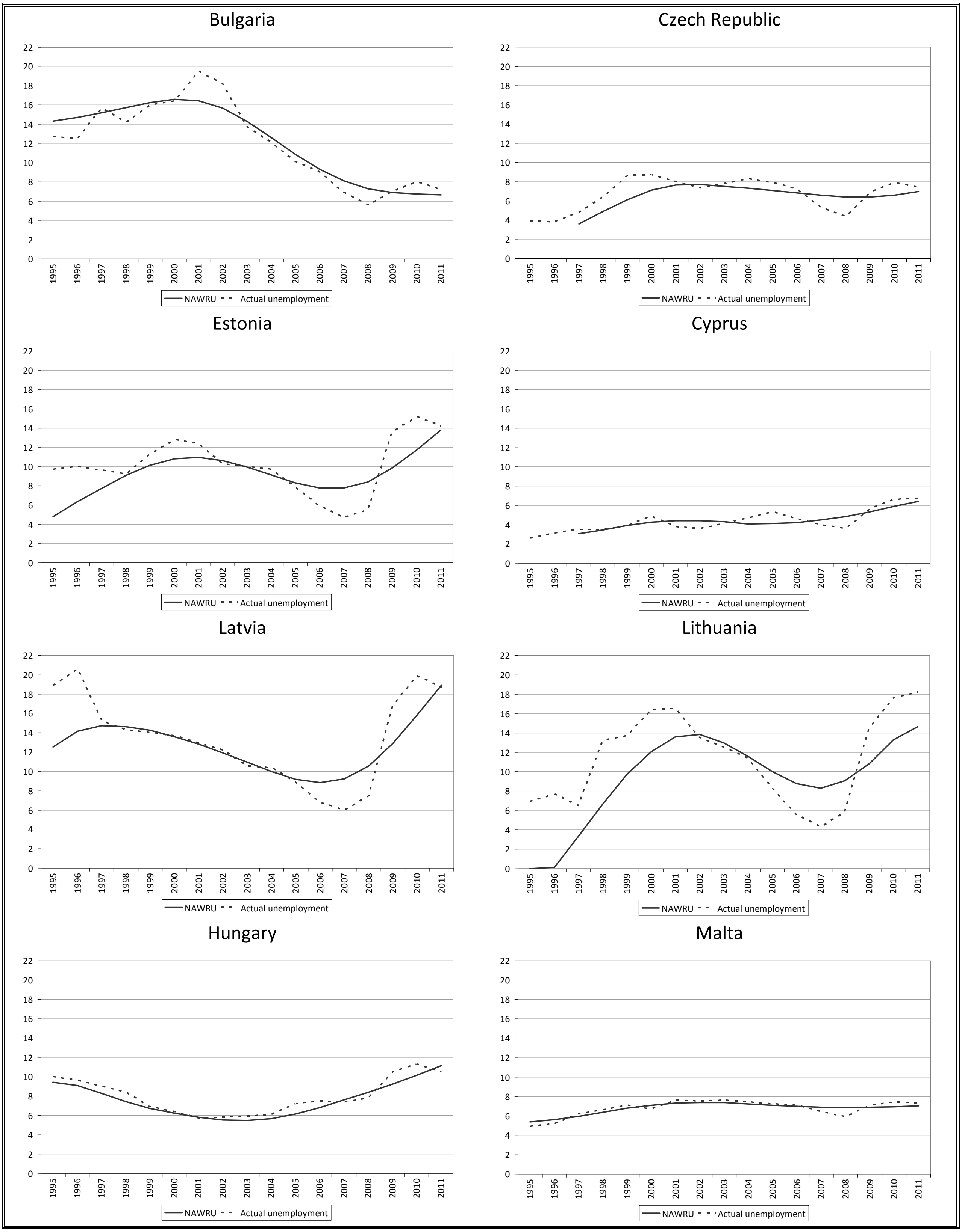


Source: Commission services

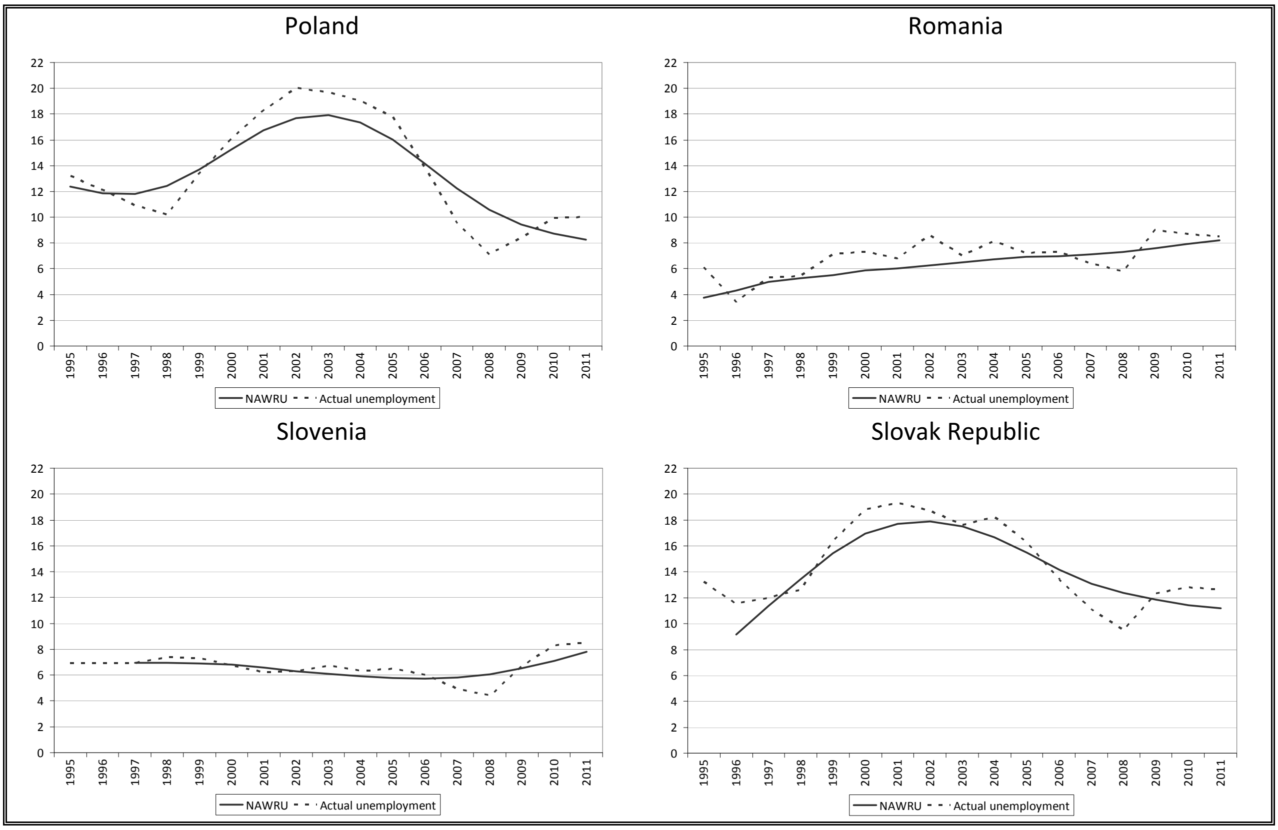


Source: Commission services

Graph 3: EU's "New" Member States - NAWRU estimates



Source: Commission services



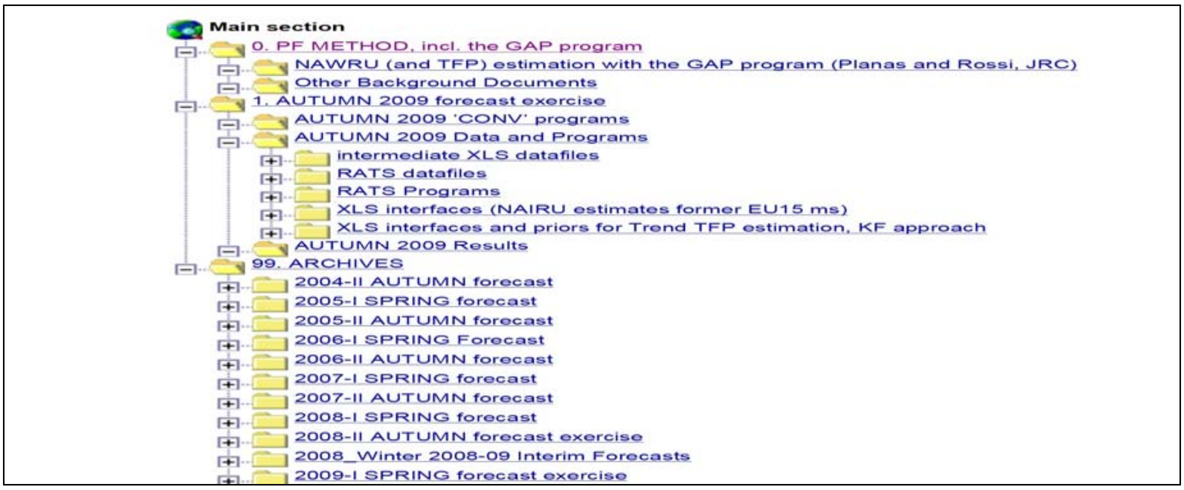
Source: Commission services

ANNEX 3 : "OUTPUT GAPS" INTERNET WEBSITE
HTTP://CIRCA.EUROPA.EU/PUBLIC/IRC/ECFIN/OUTGAPS
- VEHICLE FOR THE PUBLIC DISSEMINATION OF THE POTENTIAL GROWTH & OUTPUT GAP ESTIMATES PRODUCED BY THE PF METHODOLOGY -

An internet website, which takes the form of a publicly accessible CIRCA Interest Group[62], has been set up and dedicated to the dissemination of the output gap estimates produced using the methodology described in this paper. The operational details of the Production Function method have been agreed in the EPC's Output Gap Working Group (OGWG), and in a transparent and collaborative spirit, the results of the bi-annual operation of the method (including all technical information as well as the underlying data sets and programs) are made available to its members as well as to the wider public. This enables all interested parties to replicate and test alternative scenarios, including scenarios linked to the submission of the Stability and Convergence programmes.

CIRCA collaborative workspaces have many possibilities. In the specific case of the one used for the "Output Gaps", the option has been taken to use it mainly as a repository for essential files (main documents, results, programs, data etc). This approach enables the easy dissemination of relevant information by simply allowing users to view and download the material uploaded in a central workspace. It is designed as a publicly accessible website (i.e. no registration / identification / password is needed to access it).

The figure below gives a complete view of the organisation of the "library" part of the website: http://circa.europa.eu/Public/irc/ecfin/outgaps/library. Note that the "view" given corresponds to the situation prevailing at the beginning of 2010, the exact content being bound to evolve with the addition of new data and program files. However, the general organisation, structured around three main sections, is conserved across the successive updates.



[62] CIRCA stands for Communication and Information Resource Centre Administrator. In a way ***CIRCA Interest groups*** can be seen as predecessors of "wiki's", tailored to the needs of public administrations wishing to efficiently organise the collaborative work of committees whose members have various affiliations. ***CIRCA*** is an extranet tool, developed under the European Commission's IDA programme. It enables a given community (e.g. a committee, working group, project group etc.), geographically spread across Europe (and beyond), to maintain a private / public space on the Internet where they can share information, documents, participate in discussion fora and benefit from various other functionalities. Such a private space is called an '***Interest Group***'. (More information on http://circa.europa.eu/Public/irc/ecfin/outgaps/home?contact_info)

The three main sections are the following :

- the METHOD section;
- the CURRENT data programs and results section;
- the ARCHIVES section (i.e. previous vintages of data programs and results).

THE METHOD SECTION (INCLUDING THE GAP PROGRAM) : This section of the website is reserved for documents which describe the method and its operation. Along with a copy of the present Economic Paper, there is a special subsection on the "GAP" program which is used for estimating both trend TFP and the NAWRU (as described in sections 2 and 3 of the present paper). The program itself, as well as the official documentation and a recent paper on the use of the "GAP" programme to calculate trend TFP, can be found there. The "other background documents" sub-section includes a description of the variables used in the main programme, together with the previous reference documents.

THE DATA PROGRAMS AND RESULTS SECTIONS, ORGANISED INTO CURRENT AND ARCHIVES SECTIONS : There are two estimation exercises per year using the PF approach, linked to ECFIN's main Spring and Autumn forecasting exercises.[63] The CURRENT section includes the programs and data files used in the most recent forecasting exercise. Once a new exercise is completed and made public, the previous "current" files are moved to the ARCHIVE section. This section includes vintages of data and programs since the Autumn 2004 vintage.

These sections are essentially organised in the same way: a "*Results*" subsection; another containing "*Data and Program*" files; and (especially for the Autumn vintages) a third subsection ("*Conv*") which contains an adapted version of the main PF program files which can be used for the easy assessment of alternative scenarios (typically the assessment of stability and convergence programmes). Information is given for the 27 member states, the Euro area (EA12), US and Japan.[64]

- The "*Results*" subsection includes the detailed spreadsheets and sets of graphs for the different countries, comparable to the tables and graphs presented in Annex 6. These results are directly accessible there for each country.

- In RATS "*Data and Programs"* you will find the files actually used to estimate the potential growth rates and output gaps. Program files are written in RATS (Estima©). There are specific program versions for the "old" and "new" Member States. The programs make use of several data sets :

- a general data file with economic information (usually named according to the corresponding forecast exercise: *spr10.rat* for example). Information is taken from the ECFIN AMECO database (see Box A1 for a variable description),
- a file with NAWRU series (for the "old" member states, obtained from a separate program: *nairu_spr10.rat*),
- a file with TFP trend series (for the "old" member states, obtained from a separate program, starting in Spring 2010),
- information obtained from the Groningen Growth & Development Centre (GGDC) to complement the OECD hours worked data (*GGDC_01_2010.rat*),

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[63] Due to exceptional circumstances, an extended interim forecast exercise, including the estimation of output gaps, was carried out in Winter 2008-09. In normal circumstances, the interim forecast exercises are limited to some countries and do not include output gap re-estimation.

[64] Bulgaria and Romania were added since the Autumn 2006 exercise; Japan since Autumn 2009.

- population of working age projections obtained from EUROSTAT (*popw_2008_CORR.rat*).

The data sets have a Rats specific data format but the same information is also provided in Excel format, which allows for easy data inspection.

- The *"Excel interfaces"*, to be used in conjunction with the GAP programme for the estimation of the NAWRU of the "old" EU15 countries, are grouped into a special subsection. There is one detailed spreadsheet file per country, including specific data sets and settings, as well as a group of NAWRU related graphs.

- Likewise, the corresponding sub-section relating to the *Estimation of trend TFP* by the GAP program, contains priors and XLS interfaces per country.

- The subsection *"CONV"* contains the variant of the RATS programs dedicated to the assessment of alternative scenarios. These programs should be used in conjunction with the basic data files described above, plus the special *conv.rat* file containing the specific alternative scenario. An example of this file is also given, both in RATS and Excel formats. It typically contains a forecast scenario for only one country. The forecast range can vary (the program asks for the first and last years of the member state data scenario).

CONCLUDING REMARKS : The CIRCA website is a very effective tool for disseminating the estimates produced by the PF methodology to all interested parties. It also helps in the preparation and examination of the Stability and Convergence programmes from the Member States. The whole website acts as a form of "institutional memory" for all of the previous estimation exercises, as well as for the methodological changes which have been introduced in the method over the last number of years. It is widely regarded as a very valuable information tool for academics and policy makers working in the field of potential output and output gaps.

Box A1. Description of Variables in the Main Data File*

Data code	*Short Description*	*AMECO codes*
*GDPN / **GDPQ***	*Nominal/**real GDP***	*UVGD / **OVGD***
*IN/**IQ***	*Nominal/**real investments (GFCF, total)***	*UIGT / **OIGT***
KT**	***Capital stock***	***OKND***
LF	*Labour force*	*NLCN*
SLED	***Employment (persons)***	***NETD***
LU	*Unemployment (persons)*	*NUTN*
LUR	***Unemployment rate (harmonised)***	***ZUTN***
GDPHP	*Trend GDP (HP filter method)*	*OVGDT*
POPA	***Population of working age***	***NPAN***
UWCD	*Compensation of employees*	*UWCD*
HWCDW	*Nominal compensation per employee*	*HWCDW*
HPERE	***Average annual hours worked per employee***	***NLHA***

From this file we only use GDPQ, IQ, KT, SLED, LUR, POPA and HPERE (LF is recalculated as = SLE / (1-LUR)).*

*** For the "New" Member States, the capital stock KT is usually not available. It is therefore recalculated within the program for these Member States.*

ANNEX 4 : AN ASSESSMENT OF THE CASE FOR USING QUARTERLY DATA SERIES IN THE PF METHODOLOGY

Logically speaking, there would appear to be a strong prima facie case for exploiting the information content of quarterly series for potential growth and output gap calculations. A quarterly, rather than an annual, frequency is arguably more appropriate in tracing the evolution of the business cycle and for assessing whether the economy is operating above or below potential. However, while the case for making such a move may appear strong, there are a number of considerations which must be taken into account in making any definitive assessment. Consequently, in analysing the case for using quarterly series, this annex needs to address 2 fundamental issues : firstly, is it feasible to move to a quarterly profile from the perspective of the availability and reliability of the different data series used in the production function approach and secondly, and more importantly, would the use of quarterly series lead to more reliable real time output gap estimates ?

1 : Is it feasible to move to a quarterly profile ? : Whilst there are a number of econometric estimation issues to be resolved (different lag structures; handling seasonality etc), the issue of feasibility essentially involves firstly an assessment of the availability at the Member State level of the basic statistical series used in the production function method and secondly whether reliable forecasts for these variables can be provided for these series ?

In terms of data availability, there are six essential series needed to calculate quarterly potential growth rates : GDP, gross fixed capital formation (GFCF), employment, unemployment, population of working age and hours worked. With respect to GDP and GFCF, quarterly data is currently available for 23 of the 27 member states from 1995 and from the year 2000 for the remaining four countries, namely Greece, Malta, Romania & Bulgaria. All series are seasonally adjusted and working day adjusted (except for Bulgaria but this can easily be overcome). In terms of timeliness, both series are available with a roughly two month time delay. For the employment, unemployment & population of working age series, quarterly series are available for all countries from 2000 (with longer series existing for some countries), with normally a two to three month time lag. Finally, there are real problems to be overcome with respect to the hours worked series since data is generally only available from quarter 1 of 2008.

As to the question of the availability of forecast data for the basic series, currently quarterly forecasts from the Commission services are only published for one of the six series, namely GDP and this only occurs for 22 out of the 27 countries. No forecasts exist for any of the components of GDP (most notably GFCF) or for any of the labour market variables. In addition, there are also quality / volatility issues to be considered, especially for a number of the smaller Member States. These problems need to be addressed at the Member State level in order that, at a minimum, reliable quarterly GDP forecasts can be provided in the future. In addition, the provision of forecasts for the different components of GDP or for the labour market has clear resource implications for the Commission services and an assessment of the costs involved must not be forgotten in any evaluation exercise.

In overall terms therefore, whilst a move to a quarterly profile may be technically feasible, there are still sizeable problems to be overcome, firstly with respect to the availability of historical hours worked data & secondly in having longer time series for many of the basic variables. In addition, with respect to the forecast data, quarterly forecasts are currently only available for GDP and not for all of the EU's Member States, with issues of quality / reliability and resource implications all needing to be considered before a definitive judgement could be made.

2. Would the use of quarterly series lead to more reliable real time output gap estimates ? : The second key issue to be addressed is whether a shift to a quarterly profile would lead to more reliable real time output gap estimates ? In this respect, the literature (see, for example, Orphanides & Van Norden -2001) stresses two main sources of output gap uncertainty. One source is "data uncertainty", linked with the ex post revision of published data - although data revisions generally only explain a small proportion of the problem. The bulk of the uncertainty problem is widely considered to be due to the pervasive unreliability of end-of-sample estimates / forecasts of potential / actual GDP. This unreliability simply reflects the fact that without knowledge of the future, it is extremely difficult to make a reliable distinction between cycle and trend. The key question therefore is whether the use of quarterly data series can help with either of these two sources of output gap uncertainty and in particular, will it help us to more easily detect shifts in the levels or growth rates of potential in real time.

2.1 : Would the use of quarterly data help with data uncertainty ? At the outset it is important to stress that there is always a trade-off between the reliability & the timeliness of statistical estimates. The most accurate and reliable statistics for GDP, for example, only occur after all the available data sources have been exploited and integrated within a supply-use framework. Typically, this only occurs 2-3 years after the initial release of the data. Over this period, there are in fact five main sources of revisions to actual GDP, all of which can have a substantial effect on the timing and magnitude of the peaks & troughs of the economic cycle. Three of these sources apply to both quarterly & annual series (i.e. the incorporation of additional & improved data; the introduction of methodological changes & the re-basing & re-weighting of the constant price series). Two sources of revisions are specific to quarterly series (i.e the re-estimation of seasonal factors for seasonally adjusted series and the reconciliation of quarterly to annual measures).

What are the key drivers of the "seasonal" / "reconciliation" revisions which are specific to quarterly series ? With respect to seasonally adjusted series, revisions frequently occur since end-of-sample seasonal factors are particularly difficult to estimate. Consequently, when a new estimate is added to the end of the series, statistical offices generally re-estimate the seasonal factors for all of the quarters and this unfortunately can lead to significant revisions to the seasonally adjusted estimates, particularly for the most recent quarters. "Reconciliation" revisions, on the other hand, are driven by the fact that the reconciliation process is always done from quarterly to annual (not the other way around due to the perceived higher quality of the annual series). Once the annual measure is compiled – the quarterly estimates are revised to ensure agreement and, later on, when the annual estimates are finally balanced within the supply-use framework, this in turn provokes further revisions to the quarterly series. Consequently, given the additional sources of data revision which are specific to quarterly series, there is a clear need to assess the risk that a move to a quarterly profile could in fact add to the existing data uncertainty associated with annual series.

2.2 Would the use of quarterly series improve the reliability of end-of-sample estimates / forecasts of potential / actual GDP ? : Currently, with respect to forecasts of actual GDP, the country desk officers in the Commission services already use all of the available data sources (monthly, quarterly) to produce their forecasts. These desk officers are generally in the best position to assess the quality & informational content of quarterly series and to integrate this information into their annual forecasts. With respect to forecasts of potential, whilst in principle these should be improved by better exploiting the informational content of quarterly series, this may not be the case in practice since :

- Firstly, as stressed earlier, there are considerable reliability issues which need to be addressed;
- Secondly, the short sample lengths for many of the series (with many of them only available from 2000) means that there are less economic cycles / turning points to work with (& turning points are where the greatest revisions to real time estimates occur); and
- Finally, moving to a quarterly profile may yield very little in terms of additional reliability since the current method can, to a certain extent, exploit monthly / quarterly data where necessary. A good example of the merits of the existing approach is the new TFP methodology (described earlier in section 2 of the main text), with the latter drawing heavily on the informational content of monthly capacity utilisation survey data.

3. Concluding Remarks : In terms of moving to a quarterly profile, it is clear from this annex that there are still some issues to be resolved with respect to the feasibility and usefulness of doing so. Regarding the question of feasibility, there are in fact a number of pressing data quality & data availability issues to be overcome and, as always, there are resource implications to be considered. With respect to the economic usefulness of using quarterly, as opposed to annual, data, it is at least debatable whether there are gains to be made in reducing the inherent unreliability of real time output gap estimates. Firstly, data uncertainty could in fact be exacerbated since quarterly series tend to be prone to greater revisions over time compared with annual series (essentially since the initial preliminary or "flash" quarterly estimates are based on very little "hard" information). Secondly, any reductions in output gap uncertainty are likely to be small since forecasts of actual / potential GDP already, to an extent, exploit quarterly and indeed monthly information. Given the above considerations, there is a strong case for continuing with the existing eclectic approach whereby all useful information sources are exploited, irrespective of periodicity[65].

[65] An important point to note in considering the advantages of moving to a quarterly profile is that the fiscal surveillance process is currently solely based on annual, not quarterly, fiscal data. In addition, it is still very much an open question as to whether a move to quarterly general government accounts would significantly improve the quality of the surveillance process, given the acknowledged shortcomings of those accounts with respect to the coverage of important government revenue and expenditure items.

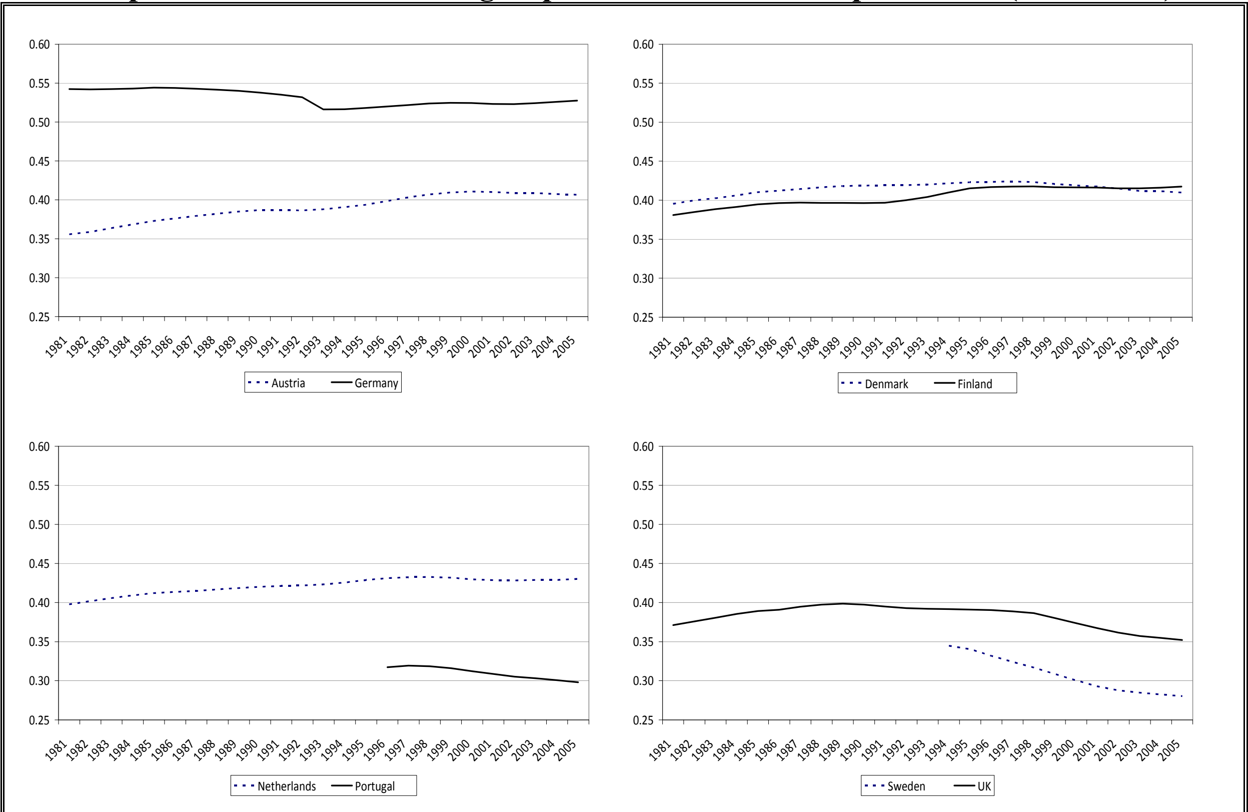
ANNEX 5 : DISAGGREGATING THE CAPITAL STOCK INTO ITS HOUSING & "NON-HOUSING" COMPONENTS - ADDITIONAL TABLES AND GRAPHS

Table 1 : Real Capital Stock

	Real Fixed Capital Stock – (Growth Rates %)						Share of Building Capital Stock in Total Capital Stock	
	Building		Non-Building		Total			
	1981-1995	1996-2005	1981-1995	1996-2005	1981-1995	1996-2005	1981-1995	1996-2005
Austria	3.2	2.5	2.0	2.2	2.4	2.3	0.38	0.41
Germany	3.1	2.5	3.7	2.2	3.3	2.3	0.54	0.52
Denmark	1.4	1.7	0.6	2.3	0.9	2.0	0.41	0.42
Finland	3.8	2.5	2.8	2.4	3.2	2.4	0.40	0.42
Netherlands	2.7	2.6	1.7	2.6	2.1	2.6	0.42	0.43
Portugal		5.2		6.2		5.9		0.31
Sweden		1.3		3.9		3.1		0.30
UK	2.9	2.1	2.3	3.9	2.6	3.3	0.39	0.37
Weighted Average	2.9	2.4	2.8	3.0	2.8	2.8	0.46	0.44

Source : EU KLEMS

Graph 1 : % Share of Building Capital Stock in Total Capital Stock (1981- 2005)



Source: EU KLEMS

Table 2 : Capital Compensation

	Capital Compensation – (Growth Rates %)						Share of Housing Capital Compensation (i.e. rental income) in Total Capital Compensation	
	Building		Non-Building		Total			
	1981-1995	1996-2005	1981-1995	1996-2005	1981-1995	1996-2005	1981-1995	1996-2005
Austria	9.3	4.3	6.3	4.5	6.8	4.5	0.17	0.18
Germany	8.1	2.2	5.8	2.9	6.4	2.7	0.27	0.31
Denmark	17.0	2.1	6.4	3.8	7.6	3.5	0.16	0.18
Finland	9.0	6.2	7.8	4.7	8.0	5.1	0.20	0.21
Netherlands	6.7	4.6	5.3	5.7	5.6	5.5	0.19	0.21
Portugal		5.5		5.4		5.4		0.17
Sweden		2.5		3.8		3.5		0.24
UK	13.3	4.1	7.0	4.1	7.8	4.1	0.11	0.20
Weighted Average	10.2	3.4	6.2	3.8	6.9	3.7	0.20	0.24

Source : EU KLEMS

Graph 2 : % Share of Building Capital Compensation in Total Capital Compensation (1981- 2005)

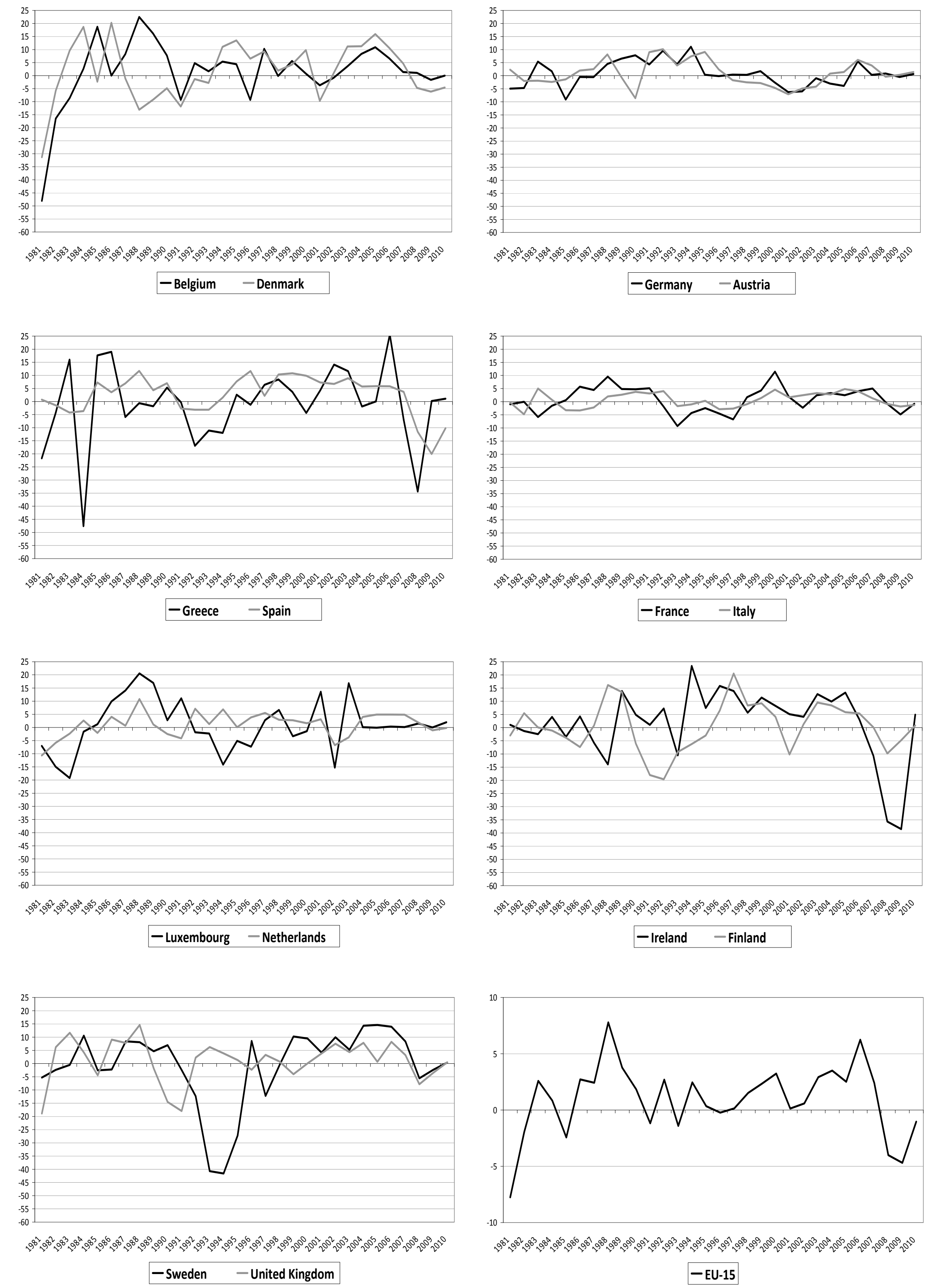
Source: EU KLEMS

Table 3 : Building and non-building investment series (Gross Fixed Capital Formation)

	Average Annual Growth Rates									Building Investment (Real Share of Total Investment)			Building Investment (Nominal Share of Total Investment)		
	Building			Non-Building			Total								
	1981-1995	1996-2006	2007-2010	1981-1995	1996-2006	2007-2010	1981-1995	1996-2006	2007-2010	1981-1995	1996-2006	2007-2010	1981-1995	1996-2006	2007-2010
Belgium	0,6	2,9	0,2	1,6	3,4	3,3	1,4	3,3	2,6	0,22	0,23	0,23	0,21	0,24	0,27
Bulgaria								9,6	13,1						
Czech Republic		3,2	7,1		2,5	4,4		2,6	4,7		0,11	0,11		0,11	0,13
Denmark	-0,7	6,5	-2,7	5,5	3,9	-0,2	3,5	4,6	-0,9	0,29	0,24	0,28	0,21	0,24	0,30
Germany	2,4	-1,3	0,3	1,7	2,0	2,6	1,9	0,9	2,0	0,33	0,33	0,27	0,29	0,33	0,30
Estonia								12,0	-2,1						
Ireland	2,0	9,4	-20,0	0,8	8,6	-3,1	1,2	8,9	-8,8	0,37	0,39	0,34	0,26	0,39	0,43
Greece	-4,1	6,0	-10,0	2,9	8,0	4,0	-1,0	7,2	-0,4	0,59	0,35	0,31	0,56	0,35	0,32
Spain	2,2	7,7	-9,5	3,6	5,6	0,9	3,3	6,1	-1,4	0,23	0,24	0,24	0,21	0,25	0,28
France	0,6	1,6	-0,3	1,4	4,3	1,1	1,1	3,5	0,7	0,36	0,28	0,26	0,32	0,28	0,29
Italy	0,3	1,7	-0,7	1,4	2,9	-0,8	1,1	2,6	-0,7	0,26	0,22	0,23	0,25	0,22	0,24
Cyprus		4,2	1,6		4,5	7,8		4,4	5,6		0,35	0,35		0,36	0,40
Latvia								16,5	-4,1						
Lithuania		6,0	0,8		11,9	0,8		11,2	0,8		0,09	0,09		0,09	0,11
Luxembourg	0,7	1,2	0,9	4,4	6,2	3,7	3,6	5,5	3,4	0,22	0,12	0,10	0,20	0,13	0,11
Hungary								6,1	1,5						
Malta								0,0	-3,4						
Netherlands	0,5	2,1	1,3	3,2	3,7	1,9	2,2	3,2	1,8	0,34	0,28	0,27	0,27	0,28	0,32
Austria	2,5	-1,6	1,3	2,0	2,7	1,7	2,2	1,7	1,6	0,26	0,23	0,20	0,24	0,24	0,21
Poland		6,5	7,3		6,3	10,6		6,3	10,2		0,13	0,13		0,13	0,14
Portugal							2,7	2,5	0,0						
Romania								6,4	16,1						
Slovenia		4,3	7,7		7,1	6,5		6,6	6,6		0,15	0,14		0,15	0,16
Slovakia		10,2	9,2		5,2	6,2		5,5	6,5		0,10	0,08		0,10	0,09
Finland	-2,8	6,2	-3,4	0,4	4,5	4,6	-0,5	5,0	2,5	0,30	0,26	0,25	0,26	0,26	0,27
Sweden	-6,6	7,1	0,2	3,2	4,0	2,9	1,1	4,4	2,5	0,31	0,11	0,14	0,22	0,11	0,17
United Kingdom	0,6	2,7	-1,9	3,5	5,0	0,5	2,7	4,6	0,1	0,26	0,18	0,18	0,19	0,18	0,23
EU15 ("Old" Member States)	**0,9**	**2,1**	**-1,8**	**2,2**	**3,7**	**1,3**	**1,8**	**3,2**	**0,5**				**0,31**	**0,26**	**0,24**
EU12 ("New" Member States)		**6,6**	**6,9**		**6,5**	**8,9**		**6,5**	**8,5**					**0,13**	**0,13**

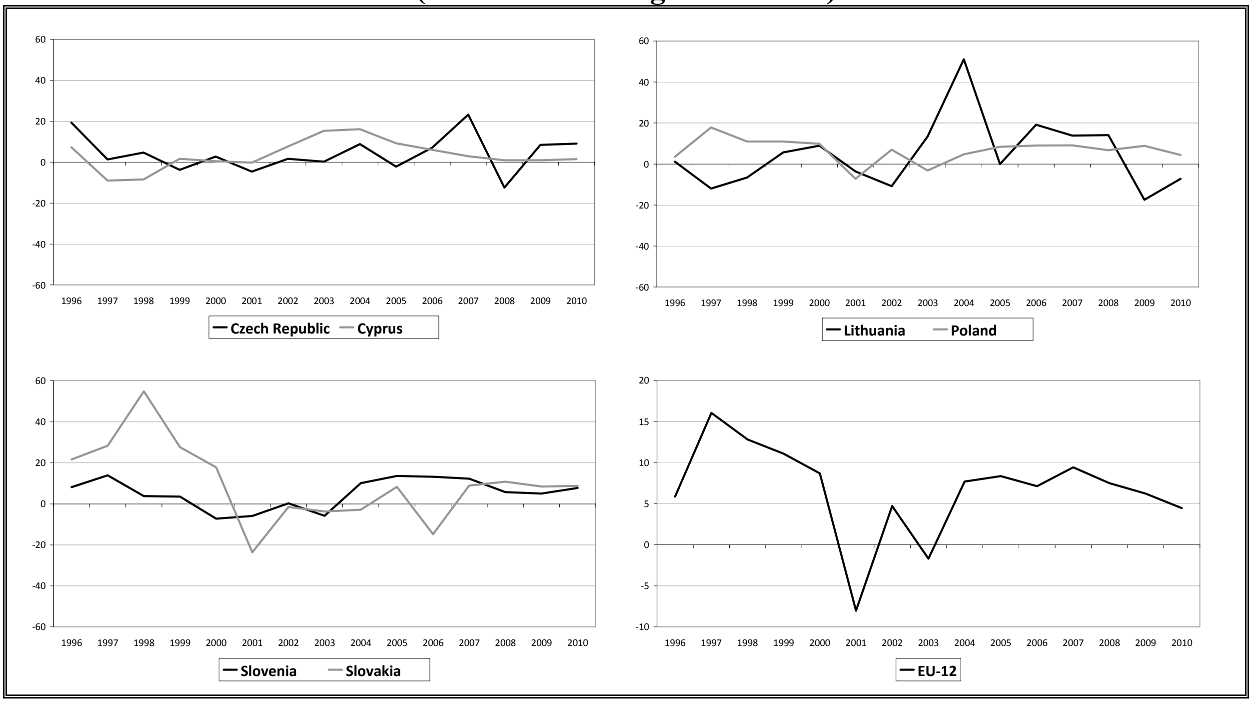
Source : AMECO

Graph 3a : Building investment series : "Old" Member States
(Annual % Change 1981-2010)



Source: Commission services

Graph 3b : Building investment series : "New" Member States (Annual % Change 1996-2010)



Source: Commission services

Table 4

uk HOUSING Variant	Output Gaps (% of Potential Output)		Potential Growth (annual % change)		Contributions to Potential Growth							Determinant of Capital Accumulation: Investment ratios			
	PF method	PF method (Housing Variant)	PF method	PF method (Housing Variant)	Total Labour (Hours) Contribution	Capital Accumulation Contribution	Capital Accumulation Contribution (Housing Variant)	*Capital Accumulation Contribution - Housing*	*Capital Accumulation Contribution - Others (non-residential)*	TFP Contribution	TFP Contribution (Housing Variant)	Investment Ratio (% of Potential Output)	Investment Ratio (Housing Variant))	*Housing Investment Ratio*	*Other (non-residential) Investment Ratio*
1981	-3,2	-3,2	1,2	1,2	-0,8	0,3	0,1	*0,0*	*0,1*	1,8	1,9	12,6	12,6	*3,6*	*9,1*
1982	-2,9	-2,9	1,8	1,8	-0,3	0,3	0,2	*0,0*	*0,1*	1,8	1,9	13,1	13,1	*3,7*	*9,4*
1983	-1,6	-1,6	2,3	2,2	0,2	0,4	0,2	*0,0*	*0,1*	1,7	1,9	13,5	13,5	*4,1*	*9,4*
1984	-1,7	-1,7	2,8	2,7	0,5	0,5	0,3	*0,1*	*0,3*	1,7	1,9	14,3	14,3	*4,1*	*10,2*
1985	-1,0	-1,0	2,8	2,8	0,6	0,5	0,4	*0,1*	*0,3*	1,7	1,8	14,5	14,5	*3,8*	*10,7*
1986	0,2	0,2	2,8	2,8	0,7	0,5	0,4	*0,1*	*0,3*	1,6	1,7	14,4	14,4	*4,1*	*10,3*
1987	1,8	1,9	2,9	2,9	0,7	0,6	0,5	*0,1*	*0,4*	1,5	1,7	15,4	15,4	*4,3*	*11,1*
1988	3,9	4,0	2,9	2,9	0,6	0,8	0,7	*0,1*	*0,6*	1,5	1,6	17,1	17,1	*4,8*	*12,3*
1989	3,4	3,4	2,8	2,9	0,4	0,9	0,9	*0,2*	*0,7*	1,5	1,5	17,7	17,7	*4,6*	*13,1*
1990	1,7	1,6	2,5	2,5	0,2	0,8	0,8	*0,1*	*0,7*	1,5	1,5	16,9	16,9	*3,9*	*13,0*
1991	-1,6	-1,7	1,9	1,9	-0,1	0,5	0,5	*0,1*	*0,4*	1,5	1,6	15,2	15,2	*3,2*	*12,0*
1992	-3,2	-3,3	1,8	1,8	-0,2	0,4	0,3	*0,1*	*0,3*	1,6	1,7	14,8	14,8	*3,2*	*11,6*
1993	-3,0	-3,0	1,9	1,9	-0,1	0,4	0,2	*0,0*	*0,2*	1,7	1,7	14,5	14,5	*3,4*	*11,1*
1994	-1,2	-1,1	2,4	2,3	0,2	0,4	0,3	*0,1*	*0,3*	1,8	1,8	14,8	14,8	*3,4*	*11,4*
1995	-0,8	-0,7	2,7	2,6	0,3	0,5	0,5	*0,1*	*0,4*	1,8	1,8	14,8	14,9	*3,4*	*11,5*
1996	-0,8	-0,6	2,8	2,8	0,3	0,6	0,6	*0,1*	*0,5*	1,8	1,8	15,2	15,2	*3,2*	*12,0*
1997	-0,5	-0,3	3,0	3,0	0,4	0,7	0,7	*0,1*	*0,6*	1,9	1,8	15,8	15,8	*3,2*	*12,6*
1998	-0,1	0,0	3,2	3,3	0,4	0,9	1,0	*0,2*	*0,8*	1,8	1,8	17,4	17,4	*3,1*	*14,3*
1999	0,3	0,3	3,1	3,2	0,4	0,9	1,0	*0,2*	*0,8*	1,8	1,7	17,4	17,4	*2,9*	*14,5*
2000	1,1	1,1	3,0	3,1	0,4	o	0,9	*0,2*	*0,8*	1,7	1,7	17,3	17,3	*2,8*	*14,5*
2001	0,7	0,7	2,9	2,9	0,4	0,8	0,9	*0,2*	*0,7*	1,6	1,6	17,3	17,3	*2,9*	*14,4*
2002	0,2	0,2	2,6	2,6	0,3	0,8	0,9	*0,2*	*0,7*	1,5	1,4	17,4	17,4	*3,0*	*14,4*
2003	0,6	0,6	2,4	2,4	0,2	0,8	0,9	*0,2*	*0,7*	1,4	1,3	17,2	17,2	*3,1*	*14,1*
2004	1,0	1,0	2,4	2,4	0,3	0,8	0,9	*0,2*	*0,7*	1,2	1,1	17,6	17,6	*3,2*	*14,4*
2005	0,8	0,8	2,3	2,3	0,3	0,9	0,9	*0,2*	*0,8*	1,1	1,0	17,6	17,6	*3,2*	*14,4*
2006	1,4	1,4	2,2	2,2	0,3	0,9	1,0	*0,2*	*0,8*	0,9	0,9	18,3	18,3	*3,4*	*14,9*
2007	2,5	2,5	1,9	2,0	0,1	1,0	1,1	*0,2*	*0,9*	0,8	0,8	19,2	19,2	*3,4*	*15,8*
2008	1,8	1,6	1,5	1,5	-0,1	0,8	0,9	*0,1*	*0,7*	0,7	0,7	18,1	18,1	*3,0*	*15,1*
2009	-2,9	-3,0	0,8	0,8	-0,2	0,4	0,4	*0,1*	*0,4*	0,7	0,7	15,7	15,6	*2,4*	*13,2*
2010	-3,8	-3,8	0,9	0,9	-0,1	0,4	0,3	*0,1*	*0,3*	0,7	0,7	15,2	15,1	*2,3*	*12,8*
2011			1,5	1,5	0,2	0,5	0,5	*0,1*	*0,4*	0,7	0,8	16,1	15,9	*2,5*	*13,5*
2012			1,8	1,9	0,3	0,6	0,7	*0,1*	*0,6*	0,8	0,8	17,2	16,9	*2,5*	*14,3*
2013			1,9	2,0	0,3	0,7	0,8	*0,1*	*0,7*	0,9	0,9	18,0	17,6	*2,5*	*15,1*

Source : Commission services

Table 5 : Sensitivity analysis - value of the γ parameter – UK example

Difference between the alternative specification and the usual PF method		***Potential growth***	***K accumulation contribution***	***TFP contribution***	***Output Gap***
Low value ($\gamma = 0.1$)	**1995**	-0.07	-0.08	0.01	0.18
	2000	0.07	0.17	-0.10	-0.05
	2005	0.01	0.09	-0.09	-0.04
	2010	-0.03	-0.03	0.00	-0.11
Proposed value ($\gamma = 0.3$)	**1995**	-0.05	-0.06	0.01	0.12
	2000	0.05	0.11	-0.07	-0.03
	2005	0.01	0.07	-0.06	-0.02
	2010	-0.02	-0.02	0.00	-0.08
High value ($\gamma = 0.65$)	**1995**	-0.02	-0.02	0.00	0.05
	2000	0.02	0.05	-0.03	-0.01
	2005	0.00	0.03	-0.02	-0.01
	2010	-0.01	-0.01	0.00	-0.03

Source: Commission services

Table 6 : Data Availability and Member State Coverage

	EUKLEMS Housing Capital Stock Series		AMECO Housing Investment Series		Tested or not ?
	Yes / No	**Length of Series**	**Yes / No**	**Length of Series**	
"Old" Member States					
Belgium	No		Yes	1970-2010	Y
Denmark	Yes	1976-2005	Yes	1966-2010	Y
Germany	Yes	1976-2005 (spliced series)	Yes	1960-2010 (spliced series)	Y
Ireland	No		Yes	1975-2010	Y
Greece	No		Yes	1960-2010	Not presented (default initial conditions give unusual results)
Spain	No		Yes	1970-2010	Y
France	No		Yes	1970-2010	Y
Italy	No		Yes	1970-2010	Y
Luxembourg	No		Yes	1970-2010	Y
Netherlands	Yes	1976-2005	Yes	1969-2010	Y
Austria	Yes	1976-2005	Yes	1976-2010	Y
Portugal	Yes	1995-2005	Yes	2000-2006	No (not enough data points)
Finland	Yes	1976-2005	Yes	1960-2010	Y
Sweden	Yes	1993-2005	Yes	1971-2010	Y
UK	Yes	1976-2005	Yes	1960-2010	Y
"New" Member States					
Bulgaria	No		No		No
Czech Republic	No		Yes	1995-2010	Y
Estonia	No		(1993-2010)*		No
Cyprus	No		Yes	1995-2010	Y
Latvia	No		(1995-2008)*		No
Lithuania	No		Yes	1995-2010	Y
Hungary	No		(2000-2010)*		No
Malta	No		(1995-2008)*		No
Poland	No		Yes	1995-2010	Y
Romania	No		(2002-2010)*		No
Slovenia	No		Yes	1991-2010	Y
Slovakia	No		Yes	1992;1994-2010	Y

Source: Commission services

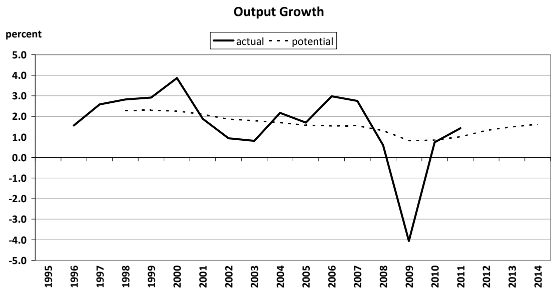
[66]Housing investment series at *current* prices exist. Using the deflators for total investment (which also exist) as a proxy to calculate series at constant prices, those series could be used in the future, when long enough

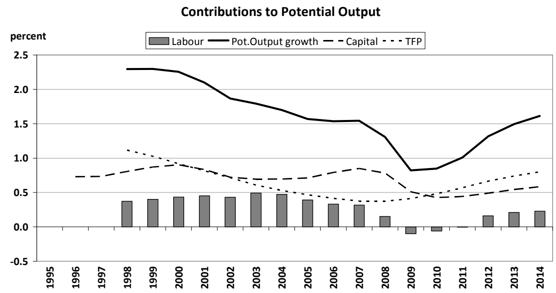
ANNEX 6 : PF METHODOLOGY RESULTS - POTENTIAL GROWTH & OUTPUT GAP TABLES & GRAPHS FOR A NUMBER OF EU AGGREGATES AS WELL AS FOR THE US & JAPAN (BASED ON THE COMMISSION SERVICES SPRING 2010 FORECASTS)

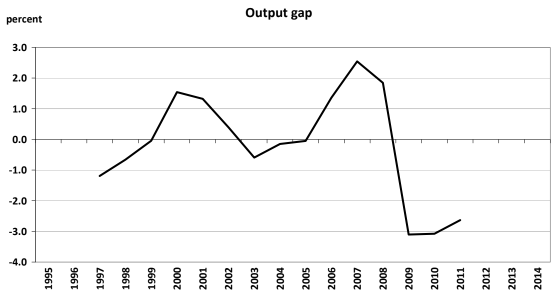
Euro Area 16

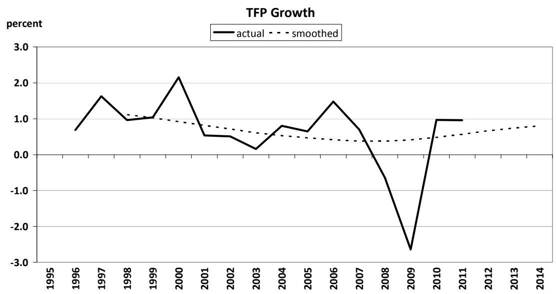
EA-16	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981														
1982														
1983														
1984														
1985														
1986														
1987														
1988														
1989														
1990														
1991														
1992														
1993														
1994														
1995	-0.9											67.5		
1996	-1.6		1.5	2.3					0.7		0.2	67.8		
1997	-1.3	-1.2	2.6	2.3					0.7		0.2	68.3	9.1	19.7
1998	-0.7	-0.7	2.8	2.3	2.3	0.4	*(0.7)*	*(-0.3)*	0.8	1.1	0.2	69.0	9.0	20.5
1999	0.0	0.0	2.9	2.3	2.3	0.4	*(0.7)*	*(-0.3)*	0.9	1.0	0.2	69.6	8.9	21.2
2000	1.6	1.5	3.9	2.2	2.3	0.4	*(0.8)*	*(-0.4)*	0.9	0.9	0.2	70.4	8.8	21.8
2001	1.4	1.3	1.9	2.1	2.1	0.5	*(0.8)*	*(-0.4)*	0.8	0.8	0.3	70.9	8.6	21.5
2002	0.4	0.4	0.9	1.9	1.9	0.4	*(0.8)*	*(-0.4)*	0.7	0.7	0.4	71.4	8.6	20.7
2003	-0.6	-0.6	0.8	1.8	1.8	0.5	*(0.8)*	*(-0.3)*	0.7	0.6	0.5	71.6	8.5	20.6
2004	-0.1	-0.1	2.2	1.7	1.7	0.5	*(0.7)*	*(-0.2)*	0.7	0.5	0.5	71.9	8.4	20.7
2005	0.1	0.0	1.7	1.5	1.6	0.4	*(0.6)*	*(-0.2)*	0.7	0.5	0.4	72.3	8.4	21.0
2006	1.7	1.4	3.0	1.3	1.5	0.3	*(0.5)*	*(-0.2)*	0.8	0.4	0.4	72.7	8.4	21.9
2007	3.2	2.5	2.8	1.2	1.5	0.3	*(0.5)*	*(-0.2)*	0.8	0.4	*0.5*	73.0	8.4	22.6
2008	2.8	1.8	0.6	1.0	1.3	0.2	*(0.3)*	*(-0.2)*	0.8	0.4	*0.4*	73.2	8.5	22.2
2009	-2.2	-3.1	-4.1	0.9	0.8	-0.1	*(0.0)*	*(-0.1)*	0.5	0.4	*0.3*	73.1	8.8	19.7
2010	-2.1	-3.1	0.7	0.8	0.8	-0.1	*(-0.0)*	*(-0.1)*	0.4	0.5	*0.1*	73.1	9.0	19.0
2011	-1.5	-2.6	1.4	0.8	1.0	0.0	*(-0.0)*	*(0.0)*	0.4	0.6	*-0.1*	73.2	9.2	19.2
2012				0.8	1.3	0.2	*(0.1)*	*(0.1)*	0.5	0.7	*-0.1*	73.5	9.3	19.6
2013				0.8	1.5	0.2	*(0.1)*	*(0.1)*	0.5	0.7	*-0.2*	73.9	9.4	20.1
2014				0.8	1.6	0.2	*(0.1)*	*(0.1)*	0.6	0.8	*-0.2*	74.2	9.4	20.4
Periods	**Period Averages**													
1981-1985														
1986-1990														
1991-1995														
1996-2000	-0.4	-0.1	2.7	2.3	2.3	0.4	(0.7)	(-0.3)	0.8	1.0	0.2	69.0	9.0	20.8
2001-2005	0.2	0.2	1.5	1.8	1.8	0.4	(0.8)	(-0.3)	0.7	0.6	0.4	71.6	8.5	20.9
2006-2011	0.3	-0.5	0.7	1.0	1.2	0.1	(0.2)	(-0.1)	0.6	0.4	0.2	73.1	8.7	20.8
2012-2014				0.8	1.5	0.2	(0.1)	(0.1)	0.5	0.7	-0.2	73.9	9.4	20.0

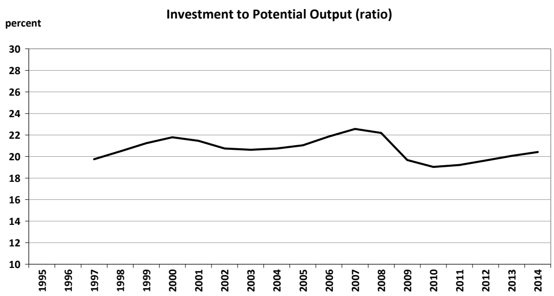
Euro Area 16

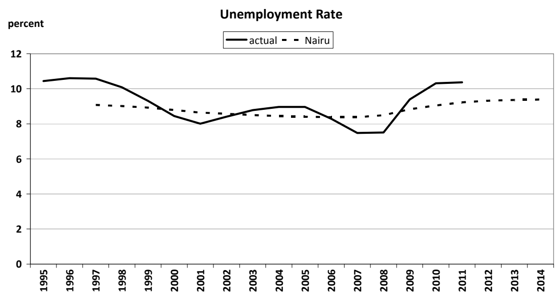

Output Growth
percent
actual
potential

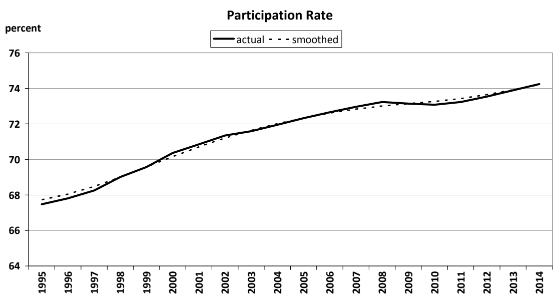

Contributions to Potential Output
percent
Labour
Pot.Output growth
Capital
TFP

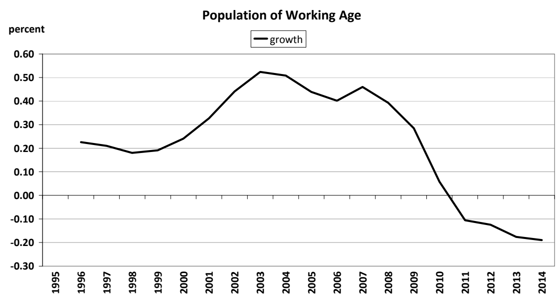

Output gap
percent

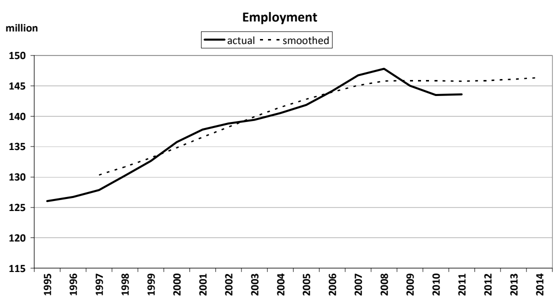

TFP Growth
percent
actual
smoothed

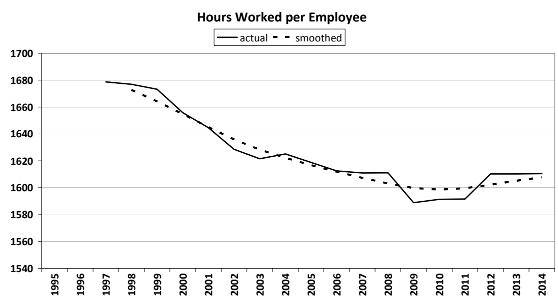

Investment to Potential Output (ratio)
percent


Unemployment Rate
percent
actual
Nairu


Participation Rate
percent
actual
smoothed


Population of Working Age
percent
growth

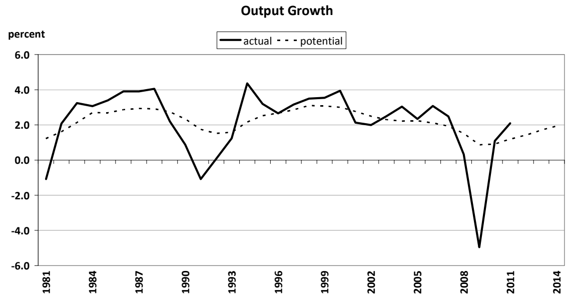

Employment
million
actual
smoothed

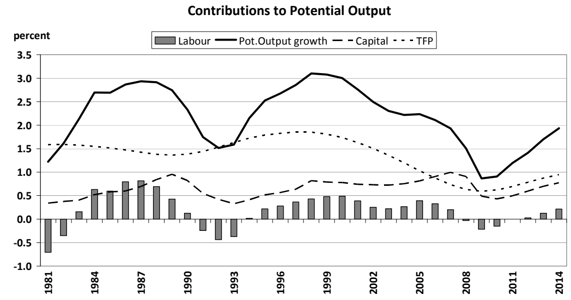

Hours Worked per Employee
actual
smoothed

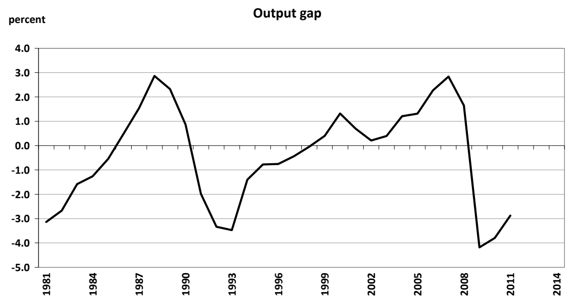
EU3 (DK, SE, UK)

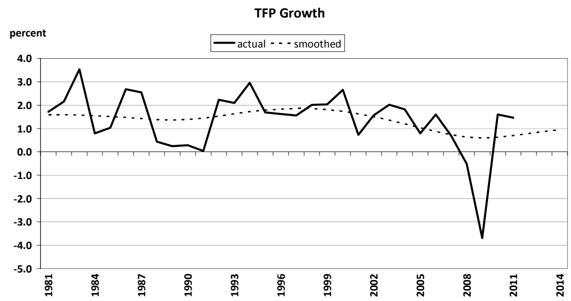
EU-3	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981	-3.6	-3.1	-1.1	1.8	1.2	-0.7	*(-0.2)*	*(-0.5)*	0.3	1.6	0.5	72.4	6.7	
1982	-3.5	-2.7	2.1	2.0	1.6	-0.4	*(-0.1)*	*(-0.3)*	0.4	1.6	0.5	72.7	7.3	13.5
1983	-2.4	-1.6	3.2	2.1	2.1	0.2	*(0.2)*	*(-0.1)*	0.4	1.6	0.7	72.2	7.8	13.9
1984	-1.7	-1.3	3.1	2.3	2.7	0.6	*(0.5)*	*(0.2)*	0.5	1.5	0.7	72.2	8.1	14.7
1985	-0.7	-0.5	3.4	2.4	2.7	0.6	*(0.3)*	*(0.3)*	0.6	1.5	0.2	72.3	8.4	15.1
1986	0.7	0.5	3.9	2.5	2.9	0.8	*(0.6)*	*(0.2)*	0.6	1.5	0.2	72.4	8.5	15.2
1987	2.3	1.5	3.9	2.5	2.9	0.8	*(0.7)*	*(0.1)*	0.7	1.4	0.2	72.1	8.4	16.1
1988	4.1	2.9	4.1	2.4	2.9	0.7	*(0.6)*	*(0.1)*	0.8	1.4	0.1	72.3	8.3	17.4
1989	4.0	2.3	2.2	2.3	2.7	0.4	*(0.5)*	*(-0.1)*	1.0	1.4	0.1	72.9	8.1	18.0
1990	2.7	0.9	0.9	2.2	2.3	0.1	*(0.3)*	*(-0.2)*	0.8	1.4	0.2	73.3	8.0	17.3
1991	-0.7	-2.0	-1.1	2.2	1.7	-0.2	*(-0.0)*	*(-0.2)*	0.5	1.4	0.1	74.0	7.9	15.7
1992	-2.7	-3.3	0.1	2.2	1.5	-0.4	*(-0.2)*	*(-0.2)*	0.4	1.5	0.0	74.5	7.9	15.1
1993	-3.6	-3.5	1.2	2.3	1.6	-0.4	*(-0.2)*	*(-0.1)*	0.3	1.6	0.1	74.5	7.9	14.4
1994	-1.8	-1.4	4.4	2.5	2.2	0.0	*(0.1)*	*(-0.0)*	0.4	1.7	0.3	74.9	7.7	14.9
1995	-1.3	-0.8	3.2	2.6	2.5	0.2	*(0.2)*	*(-0.0)*	0.5	1.8	0.4	75.2	7.4	15.2
1996	-1.3	-0.8	2.7	2.7	2.7	0.3	*(0.3)*	*(-0.0)*	0.6	1.8	0.3	74.9	7.2	15.6
1997	-1.0	-0.4	3.2	2.8	2.9	0.4	*(0.4)*	*(-0.0)*	0.6	1.9	0.3	74.8	6.8	16.1
1998	-0.4	0.0	3.5	2.9	3.1	0.4	*(0.5)*	*(-0.1)*	0.8	1.9	0.3	74.3	6.4	17.5
1999	0.2	0.4	3.5	2.9	3.1	0.5	*(0.7)*	*(-0.2)*	0.8	1.8	0.5	74.0	6.1	17.6
2000	1.3	1.3	3.9	2.9	3.0	0.5	*(0.7)*	*(-0.3)*	0.8	1.7	0.6	74.8	5.7	17.7
2001	0.6	0.7	2.1	2.8	2.8	0.4	*(0.7)*	*(-0.3)*	0.7	1.6	0.6	75.6	5.4	17.5
2002	0.1	0.2	2.0	2.6	2.5	0.3	*(0.6)*	*(-0.3)*	0.7	1.5	0.6	75.6	5.2	17.5
2003	0.1	0.4	2.5	2.4	2.3	0.2	*(0.5)*	*(-0.3)*	0.7	1.4	0.6	76.5	5.2	17.3
2004	1.0	1.2	3.0	2.2	2.2	0.3	*(0.5)*	*(-0.3)*	0.8	1.2	0.7	77.8	5.2	17.8
2005	1.4	1.3	2.3	1.9	2.2	0.4	*(0.6)*	*(-0.2)*	0.8	1.0	0.9	78.4	5.2	18.0
2006	2.8	2.3	3.1	1.7	2.1	0.3	*(0.5)*	*(-0.2)*	0.9	0.9	0.9	78.4	5.4	18.9
2007	3.9	2.8	2.5	1.4	1.9	0.2	*(0.4)*	*(-0.2)*	1.0	0.7	*0.8*	77.6	5.6	19.9
2008	3.1	1.6	0.3	1.1	1.5	0.0	*(0.2)*	*(-0.3)*	0.9	0.6	*0.6*	77.0	5.9	19.1
2009	-2.9	-4.2	-5.0	0.9	0.9	-0.2	*(0.0)*	*(-0.2)*	0.5	0.6	*0.5*	76.6	6.3	16.1
2010	-2.4	-3.8	1.1	0.8	0.9	-0.1	*(-0.0)*	*(-0.1)*	0.4	0.6	*0.4*	76.1	6.7	15.8
2011	-1.0	-2.9	2.1	0.7	1.2	0.0	*(0.0)*	*(-0.0)*	0.5	0.7	*0.4*	76.2	6.9	16.3
2012				0.7	1.4	0.0	*(-0.1)*	*(0.1)*	0.6	0.8	*0.1*	76.1	7.1	17.0
2013				0.7	1.7	0.1	*(-0.0)*	*(0.1)*	0.7	0.9	*0.1*	76.2	7.1	17.8
2014				0.7	1.9	0.2	*(0.1)*	*(0.1)*	0.8	0.9	*0.1*	76.1	7.2	18.3
Periods	**Period Averages**													
1981-1985	-2.4	-1.8	2.1	2.1	2.1	0.1	(0.2)	(-0.1)	0.4	1.6	0.5	72.4	7.7	14.3
1986-1990	2.8	1.6	3.0	2.4	2.8	0.6	(0.5)	(0.0)	0.8	1.4	0.2	72.6	8.3	16.8
1991-1995	-2.0	-2.2	1.6	2.4	1.9	-0.2	(-0.0)	(-0.1)	0.4	1.6	0.2	74.6	7.8	15.0
1996-2000	-0.2	0.1	3.4	2.9	2.9	0.4	(0.5)	(-0.1)	0.7	1.8	0.4	74.5	6.4	16.9
2001-2005	0.6	0.8	2.4	2.4	2.4	0.3	(0.6)	(-0.3)	0.8	1.3	0.7	76.8	5.2	17.6
2006-2011	0.6	-0.7	0.7	1.1	1.4	0.0	(0.2)	(-0.2)	0.7	0.7	0.6	77.0	6.1	17.7
2012-2014				0.7	1.7	0.1	(-0.0)	(0.1)	0.7	0.9	0.1	76.1	7.1	17.7

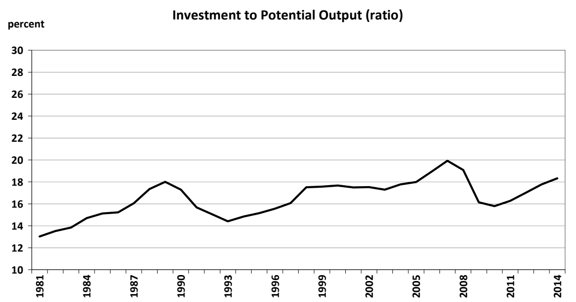
EU3 (DK, SE, UK)

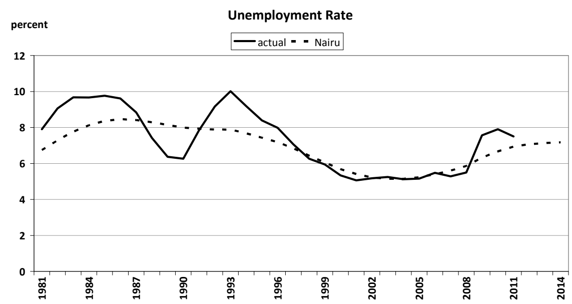

Output Growth
percent
actual
potential

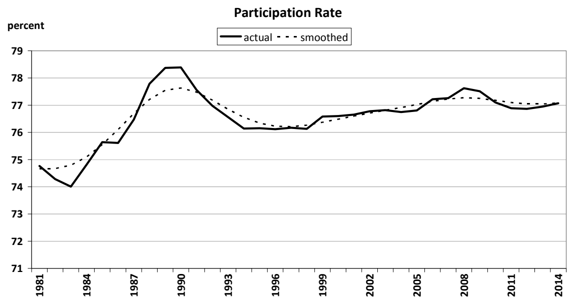

Contributions to Potential Output
percent
Labour
Pot.Output growth
Capital
TFP


Output gap
percent

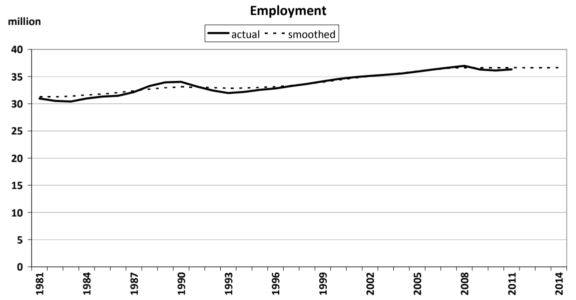

TFP Growth
percent
actual
smoothed


Investment to Potential Output (ratio)
percent


Unemployment Rate
percent
actual
Nairu


Participation Rate
percent
actual
smoothed


Population of Working Age
percent
growth

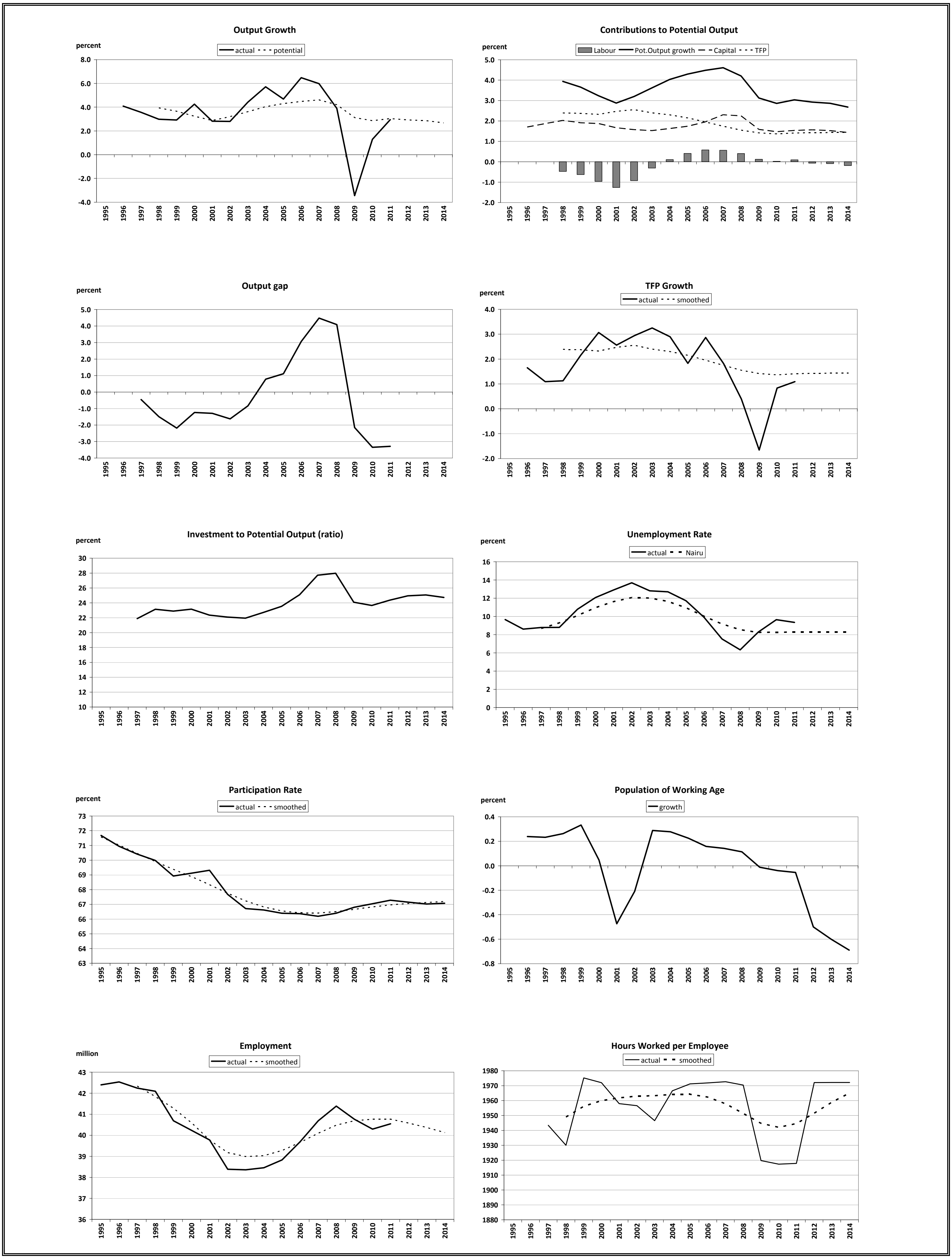

Employment
million
actual
smoothed


Hours Worked per Employee
actual
smoothed

EU8 (New Member States excl. those belonging to Euro Area)

EU-8	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981														
1982														
1983														
1984														
1985														
1986														
1987														
1988														
1989														
1990														
1991														
1992														
1993														
1994														
1995	0.6											71.7		
1996	1.0		4.1	3.6					1.7		0.2	70.9		
1997	0.6	-0.5	3.6	3.6					1.9		0.2	70.4	8.7	21.9
1998	-0.2	-1.5	3.0	3.7	3.9	-0.5	*(-0.8)*	*(0.3)*	2.0	2.4	0.3	70.0	9.3	23.1
1999	-1.0	-2.2	2.9	3.7	3.7	-0.6	*(-0.9)*	*(0.2)*	1.9	2.4	0.3	68.9	10.1	22.9
2000	-0.5	-1.2	4.3	3.8	3.2	-1.0	*(-1.1)*	*(0.1)*	1.9	2.3	0.0	69.1	11.0	23.2
2001	-1.5	-1.3	2.8	3.9	2.9	-1.3	*(-1.3)*	*(0.1)*	1.7	2.5	-0.5	69.3	11.6	22.4
2002	-2.6	-1.6	2.8	3.9	3.2	-0.9	*(-1.0)*	*(0.0)*	1.6	2.6	-0.2	67.7	12.1	22.1
2003	-2.1	-0.8	4.4	4.0	3.6	-0.3	*(-0.3)*	*(0.0)*	1.5	2.4	0.3	66.7	12.0	21.9
2004	-0.5	0.8	5.7	4.0	4.0	0.1	*(0.1)*	*(0.0)*	1.6	2.3	0.3	66.6	11.6	22.7
2005	0.2	1.1	4.7	3.9	4.3	0.4	*(0.4)*	*(0.0)*	1.7	2.2	0.2	66.4	10.9	23.5
2006	2.9	3.1	6.5	3.8	4.5	0.6	*(0.6)*	*(-0.1)*	2.0	2.0	0.2	66.4	10.0	25.1
2007	5.4	4.5	6.0	3.6	4.6	0.6	*(0.7)*	*(-0.1)*	2.3	1.7	0.1	66.2	9.2	27.7
2008	5.9	4.1	3.9	3.3	4.2	0.4	*(0.6)*	*(-0.2)*	2.3	1.5	0.1	66.4	8.5	28.0
2009	-0.4	-2.2	-3.5	3.1	3.1	0.1	*(0.3)*	*(-0.2)*	1.6	1.4	0.0	66.8	8.2	24.1
2010	-1.7	-3.3	1.3	2.9	2.9	0.0	*(0.1)*	*(-0.1)*	1.5	1.4	0.0	67.0	8.3	23.6
2011	-1.5	-3.3	3.0	2.9	3.0	0.1	*(0.0)*	*(0.1)*	1.5	1.4	-0.1	67.3	8.3	24.4
2012				2.8	2.9	-0.1	*(-0.3)*	*(0.2)*	1.6	1.4	-0.5	67.1	8.3	24.9
2013				2.8	2.9	-0.1	*(-0.3)*	*(0.2)*	1.5	1.4	-0.6	67.0	8.3	25.1
2014				2.8	2.7	-0.2	*(-0.4)*	*(0.2)*	1.4	1.4	-0.7	67.1	8.3	24.7
Periods	**Period Averages**													
1981-1985														
1986-1990														
1991-1995														
1996-2000	0.0	-1.3	3.6	3.7	3.6	-0.7	(-0.9)	(0.2)	1.9	2.4	0.2	69.9	9.8	22.8
2001-2005	-1.3	-0.4	4.1	3.9	3.6	-0.4	(-0.4)	(0.0)	1.6	2.4	0.0	67.3	11.7	22.5
2006-2011	1.7	0.5	2.9	3.3	3.7	0.3	(0.4)	(-0.1)	1.9	1.6	0.1	66.7	8.8	25.5
2012-2014				2.8	2.8	-0.1	(-0.3)	(0.2)	1.5	1.4	-0.6	67.1	8.3	24.9

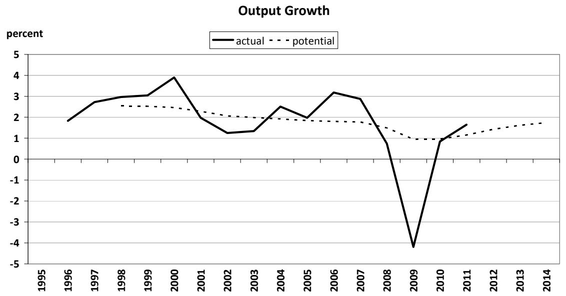
EU8 (New Member States excl. those belonging to Euro Area)

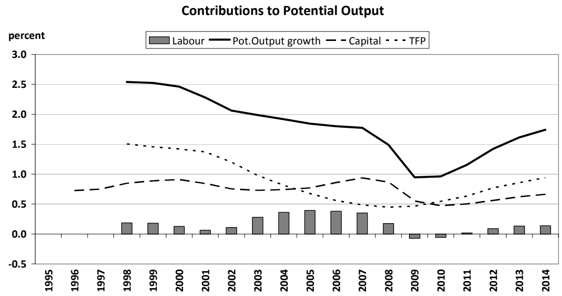


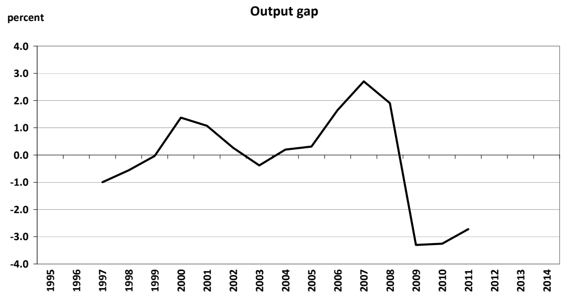
EU27

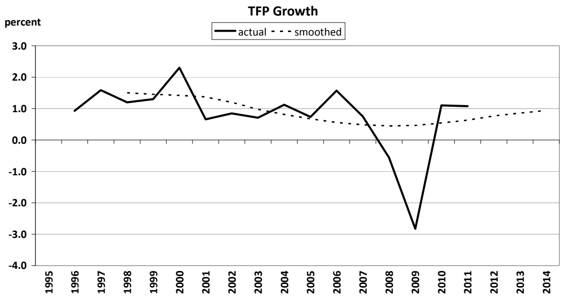
EU-27	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981														
1982														
1983														
1984														
1985														
1986														
1987														
1988														
1989														
1990														
1991														
1992														
1993														
1994														
1995														
1996	-1.4		1.8	2.4							0.2	69.7		
1997	-1.1	-1.0	2.7	2.5							0.2	69.8	8.6	19.0
1998	-0.6	-0.6	3.0	2.5	2.5	0.2	*(0.4)*	*(-0.2)*	0.8	1.5	0.2	70.3	8.7	19.9
1999	0.0	0.0	3.0	2.5	2.5	0.2	*(0.4)*	*(-0.2)*	0.9	1.5	0.3	70.5	8.7	20.5
2000	1.4	1.4	3.9	2.4	2.5	0.1	*(0.4)*	*(-0.3)*	0.9	1.4	0.3	71.0	8.7	20.9
2001	1.1	1.1	2.0	2.3	2.3	0.1	*(0.4)*	*(-0.3)*	0.8	1.4	0.2	71.4	8.7	20.6
2002	0.2	0.3	1.2	2.2	2.1	0.1	*(0.4)*	*(-0.3)*	0.8	1.2	0.3	71.4	8.7	20.1
2003	-0.5	-0.4	1.3	2.0	2.0	0.3	*(0.5)*	*(-0.3)*	0.7	1.0	0.5	71.4	8.6	19.9
2004	0.1	0.2	2.5	1.9	1.9	0.4	*(0.6)*	*(-0.2)*	0.7	0.8	0.5	71.6	8.5	20.2
2005	0.4	0.3	2.0	1.7	1.8	0.4	*(0.6)*	*(-0.2)*	0.8	0.7	0.5	71.8	8.4	20.5
2006	2.0	1.6	3.2	1.5	1.8	0.4	*(0.6)*	*(-0.2)*	0.9	0.6	0.4	72.1	8.2	21.3
2007	3.5	2.7	2.9	1.3	1.8	0.4	*(0.5)*	*(-0.2)*	0.9	0.5	*0.4*	72.3	8.1	22.2
2008	3.0	1.9	0.7	1.1	1.5	0.2	*(0.4)*	*(-0.2)*	0.9	0.4	*0.4*	72.5	8.1	21.8
2009	-2.3	-3.3	-4.2	1.0	0.9	-0.1	*(0.1)*	*(-0.2)*	0.6	0.5	*0.3*	72.5	8.3	19.1
2010	-2.2	-3.3	0.8	0.9	1.0	-0.1	*(0.0)*	*(-0.1)*	0.5	0.5	*0.1*	72.5	8.5	18.5
2011	-1.4	-2.7	1.6	0.9	1.2	0.0	*(-0.0)*	*(0.0)*	0.5	0.6	*0.0*	72.6	8.7	18.8
2012				0.9	1.4	0.1	*(-0.0)*	*(0.1)*	0.6	0.8	*-0.2*	72.8	8.8	19.3
2013				0.9	1.6	0.1	*(-0.0)*	*(0.1)*	0.6	0.9	*-0.2*	73.0	8.8	19.8
2014				0.9	1.7	0.1	*(0.0)*	*(0.1)*	0.7	0.9	*-0.2*	73.3	8.9	20.2
Periods	**Period Averages**													
1981-1985														
1986-1990														
1991-1995														
1996-2000	-0.3	-0.1	2.9	2.4	2.5	0.2	(0.4)	(-0.2)	0.9	1.5	0.2	70.2	8.7	20.1
2001-2005	0.3	0.3	1.8	2.0	2.0	0.2	(0.5)	(-0.3)	0.8	1.0	0.4	71.5	8.6	20.3
2006-2011	0.5	-0.5	0.9	1.1	1.4	0.1	(0.3)	(-0.1)	0.7	0.5	0.3	72.4	8.3	20.3
2012-2014				0.9	1.6	0.1	(-0.0)	(0.1)	0.6	0.9	-0.2	73.0	8.8	19.8

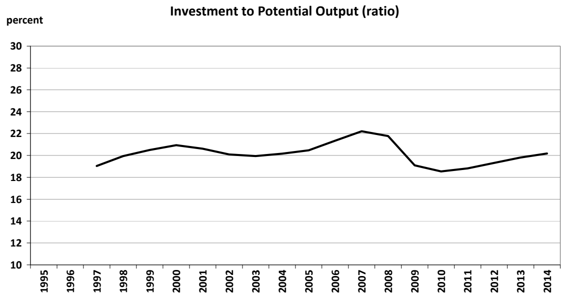
EU27


Output Growth
percent
actual
potential

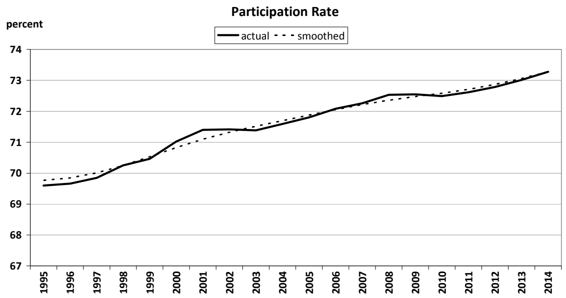

Contributions to Potential Output
percent
Labour
Pot.Output growth
Capital
TFP

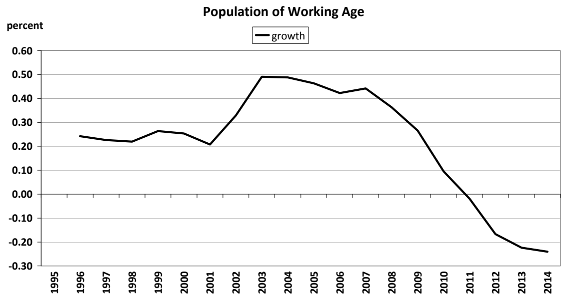

Output gap
percent

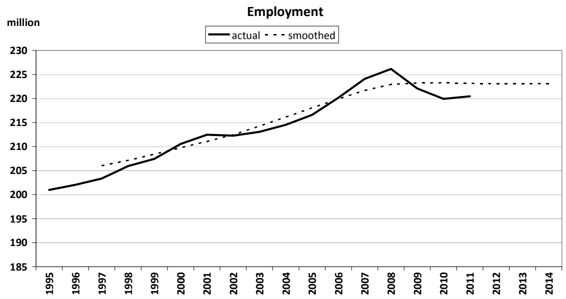

TFP Growth
percent
actual
smoothed

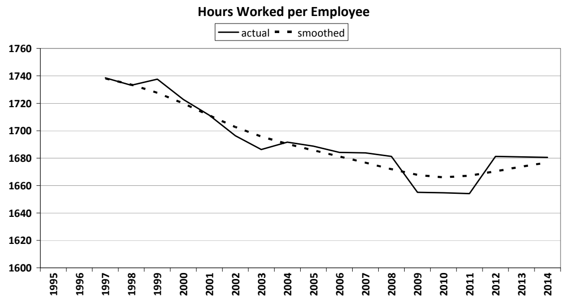

Investment to Potential Output (ratio)
percent


Unemployment Rate
percent
actual
Nairu


Participation Rate
percent
actual
smoothed


Population of Working Age
percent
growth

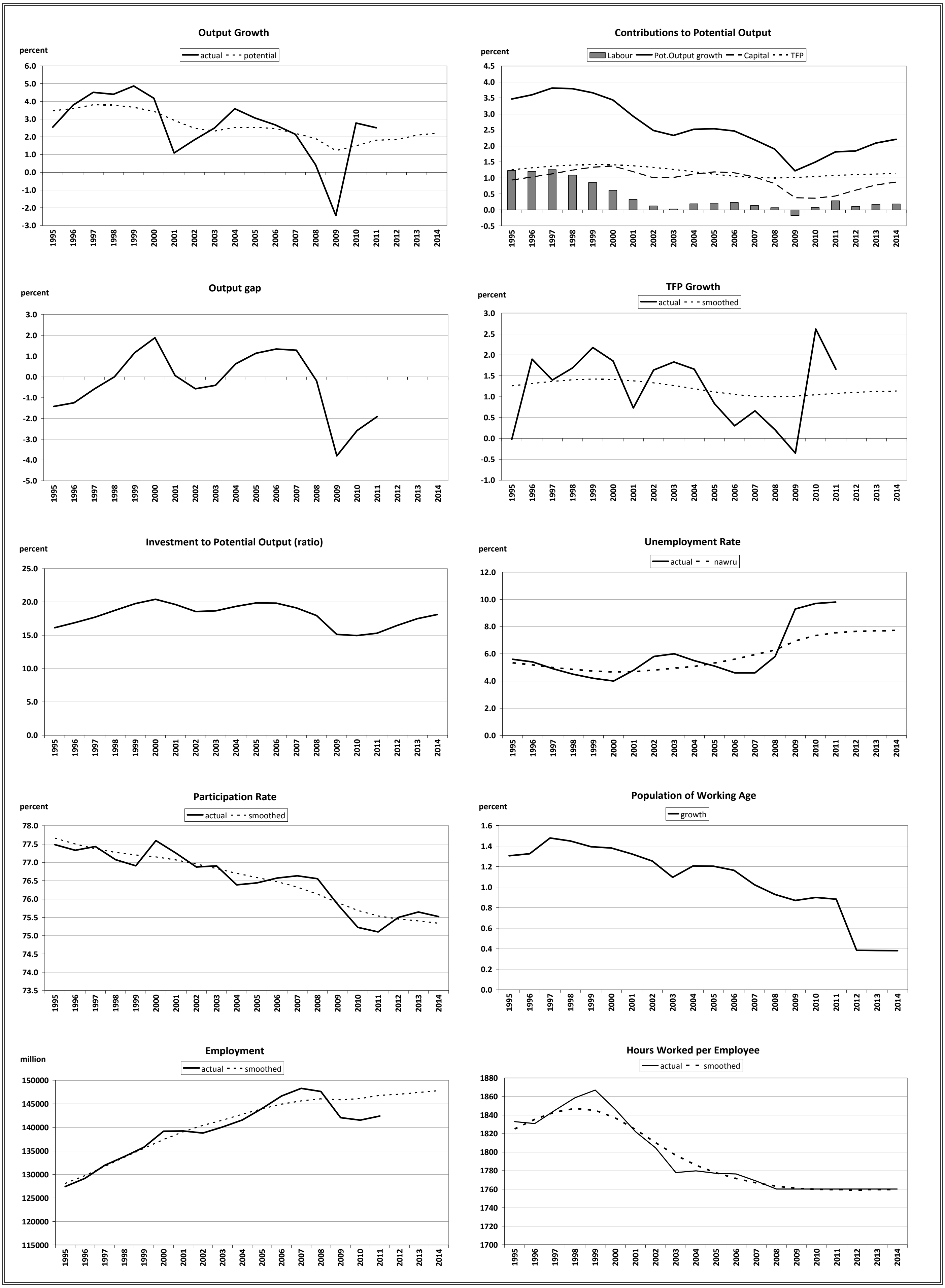

Employment
million
actual
smoothed


Hours Worked per Employee
actual
smoothed

US

US	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981	-0.3	-0.8	2.5	2.9	2.9	1.1	*(1.2)*	*(-0.1)*	0.9	0.9	1.2	72.6	7.3	15.0
1982	-5.1	-5.1	-2.0	2.9	2.5	0.9	*(0.9)*	*(0.0)*	0.6	0.9	1.0	72.9	7.4	13.7
1983	-3.7	-3.6	4.5	3.0	2.8	1.1	*(1.0)*	*(0.1)*	0.7	1.0	0.9	73.3	7.3	14.2
1984	0.1	0.0	7.2	3.1	3.4	1.3	*(1.2)*	*(0.1)*	1.0	1.1	1.0	73.7	7.1	16.0
1985	1.0	0.7	4.1	3.2	3.4	1.2	*(1.3)*	*(-0.0)*	1.0	1.1	1.0	74.4	7.0	16.4
1986	1.2	0.6	3.4	3.2	3.5	1.4	*(1.5)*	*(-0.1)*	1.0	1.1	1.0	75.2	6.8	16.1
1987	1.2	0.5	3.2	3.2	3.3	1.2	*(1.4)*	*(-0.2)*	0.9	1.1	0.8	76.1	6.5	15.8
1988	2.1	1.4	4.1	3.2	3.2	1.1	*(1.3)*	*(-0.2)*	0.9	1.1	0.7	76.9	6.3	15.7
1989	2.6	2.0	3.6	3.1	2.9	0.9	*(1.0)*	*(-0.1)*	0.9	1.1	0.6	77.6	6.2	15.8
1990	1.4	1.1	1.9	3.1	2.8	0.8	*(1.0)*	*(-0.1)*	0.8	1.1	0.8	78.0	6.1	15.3
1991	-1.9	-1.7	-0.3	3.1	2.6	0.8	*(0.9)*	*(-0.0)*	0.6	1.1	1.0	78.1	6.0	14.1
1992	-1.6	-1.2	3.4	3.1	2.8	1.0	*(0.9)*	*(0.1)*	0.7	1.1	1.2	78.1	5.9	14.5
1993	-1.9	-1.3	2.9	3.2	3.1	1.1	*(0.8)*	*(0.3)*	0.8	1.2	1.2	78.0	5.7	15.0
1994	-1.1	-0.5	4.1	3.3	3.3	1.1	*(0.8)*	*(0.4)*	0.9	1.2	1.2	77.8	5.5	15.7
1995	-1.9	-1.4	2.5	3.4	3.5	1.2	*(0.8)*	*(0.4)*	0.9	1.3	1.3	77.7	5.3	16.1
1996	-1.6	-1.2	3.8	3.4	3.6	1.2	*(0.8)*	*(0.4)*	1.0	1.3	1.3	77.5	5.2	16.9
1997	-0.6	-0.6	4.5	3.5	3.8	1.3	*(1.0)*	*(0.3)*	1.1	1.4	1.5	77.4	5.0	17.7
1998	0.3	0.0	4.4	3.4	3.8	1.1	*(1.0)*	*(0.1)*	1.2	1.4	1.4	77.3	4.8	18.8
1999	1.8	1.2	4.9	3.4	3.7	0.9	*(0.9)*	*(-0.1)*	1.3	1.4	1.4	77.2	4.7	19.7
2000	2.8	1.9	4.2	3.2	3.4	0.6	*(0.9)*	*(-0.3)*	1.4	1.4	1.4	77.2	4.7	20.4
2001	0.8	0.1	1.1	3.0	2.9	0.3	*(0.8)*	*(-0.4)*	1.2	1.4	1.3	77.1	4.7	19.6
2002	-0.2	-0.6	1.8	2.9	2.5	0.1	*(0.6)*	*(-0.5)*	1.0	1.3	1.3	77.0	4.8	18.6
2003	-0.4	-0.4	2.5	2.7	2.3	0.0	*(0.5)*	*(-0.5)*	1.0	1.3	1.1	76.8	4.9	18.7
2004	0.7	0.6	3.6	2.5	2.5	0.2	*(0.6)*	*(-0.4)*	1.1	1.2	1.2	76.7	5.1	19.3
2005	1.5	1.1	3.1	2.3	2.5	0.2	*(0.5)*	*(-0.3)*	1.2	1.1	1.2	76.6	5.3	19.9
2006	2.0	1.3	2.7	2.1	2.5	0.2	*(0.5)*	*(-0.2)*	1.2	1.1	1.2	76.5	5.6	19.8
2007	2.3	1.3	2.1	1.9	2.2	0.1	*(0.3)*	*(-0.2)*	1.0	1.0	1.0	76.3	5.9	19.1
2008	0.9	-0.2	0.4	1.8	1.9	0.1	*(0.2)*	*(-0.1)*	0.8	1.0	0.9	76.1	6.3	18.0
2009	-3.2	-3.8	-2.4	1.7	1.2	-0.2	*(-0.1)*	*(-0.1)*	0.4	1.0	0.9	75.9	6.9	15.1
2010	-2.1	-2.6	2.8	1.7	1.5	0.1	*(0.1)*	*(-0.0)*	0.4	1.0	0.9	75.7	7.3	15.0
2011	-1.3	-1.9	2.5	1.7	1.8	0.3	*(0.3)*	*(-0.0)*	0.4	1.1	0.9	75.5	7.5	15.3
2012				1.7	1.8	0.1	*(0.1)*	*(-0.0)*	0.6	1.1	0.4	75.5	7.6	16.5
2013				1.7	2.1	0.2	*(0.2)*	*(0.0)*	0.8	1.1	0.4	75.4	7.7	17.5
2014				1.7	2.2	0.2	*(0.2)*	*(0.0)*	0.9	1.1	0.4	75.3	7.7	18.1
Periods	**Period Averages**													
1981-1985	-1.6	-1.8	3.3	3.0	3.0	1.1	(1.1)	(0.0)	0.8	1.0	1.0	73.4	7.2	15.1
1986-1990	1.7	1.1	3.2	3.1	3.1	1.1	(1.2)	(-0.2)	0.9	1.1	0.8	76.7	6.4	15.7
1991-1995	-1.7	-1.2	2.5	3.2	3.0	1.0	(0.8)	(0.2)	0.8	1.2	1.2	77.9	5.7	15.1
1996-2000	0.6	0.2	4.3	3.4	3.7	1.0	(0.9)	(0.1)	1.2	1.4	1.4	77.3	4.9	18.7
2001-2005	0.5	0.2	2.4	2.7	2.6	0.2	(0.6)	(-0.4)	1.1	1.3	1.2	76.8	5.0	19.2
2006-2010	0.0	-0.8	1.1	1.8	1.9	0.1	(0.2)	(-0.1)	0.8	1.0	1.0	76.1	6.4	17.4
2011-2014				1.7	2.0	0.2	(0.2)	(-0.0)	0.7	1.1	0.5	75.4	7.7	16.9

US

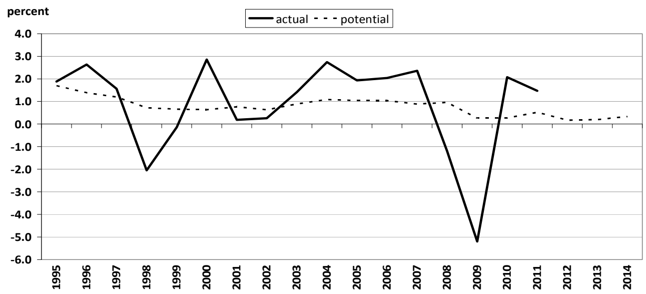

Output Growth
percent
actual
potential
Contributions to Potential Output
percent
Labour
Pot.Output growth
Capital
TFP
Output gap
percent
TFP Growth
percent
actual
smoothed
Investment to Potential Output (ratio)
percent
Unemployment Rate
percent
actual
nawru
Participation Rate
percent
actual
smoothed
Population of Working Age
percent
growth
Employment
million
actual
smoothed
Hours Worked per Employee
actual
smoothed

Japan

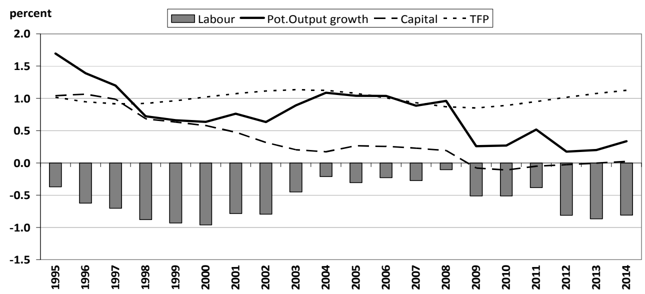
JP	Output Gaps (% of Potential Output)		Actual Output Growth (annual % change)	Potential Growth (annual % change)		Contributions to Potential Growth*					Determinants of Labour Potential and Capital Accumulation			
	HP Filter	PF method		HP Trend Growth	PF Potential Growth	Total Labour (Hours) Contribution	*Labour (persons) Contribution*	*Changes in Hours (per Empl) Contribution*	Capital Accumulation Contribution	TFP Contribution	Growth of Working Age Population (annual % change)	Trend Participation Rate (% of Working Age Population)	NAIRU (% of Labour Force)	Investment Ratio (% of Potential Output)
1981	-1.0	-1.2	4.2	4.1	3.9	0.2	*(0.3)*	*(-0.1)*	1.9	1.7	0.5	76.2	2.0	26.5
1982	-1.7	-1.9	3.4	4.1	4.1	0.5	*(0.6)*	*(-0.1)*	1.7	1.8	1.0	76.2	2.1	25.4
1983	-2.8	-2.7	3.1	4.2	4.0	0.5	*(0.5)*	*(-0.1)*	1.5	1.9	1.0	76.2	2.3	24.1
1984	-2.6	-2.4	4.5	4.2	4.1	0.5	*(0.5)*	*(-0.1)*	1.5	2.1	1.1	76.0	2.4	24.2
1985	-0.6	-0.3	6.3	4.3	4.1	0.3	*(0.4)*	*(-0.1)*	1.5	2.2	0.9	75.8	2.4	25.2
1986	-2.0	-1.5	2.8	4.3	4.2	0.3	*(0.5)*	*(-0.1)*	1.5	2.2	1.0	75.7	2.5	25.5
1987	-2.1	-1.6	4.1	4.2	4.2	0.3	*(0.6)*	*(-0.3)*	1.6	2.3	1.0	75.6	2.5	26.4
1988	0.8	0.9	7.1	4.1	4.4	0.3	*(0.8)*	*(-0.4)*	1.8	2.2	1.0	75.7	2.4	28.7
1989	2.3	2.0	5.4	3.8	4.3	0.2	*(0.9)*	*(-0.7)*	1.9	2.1	0.9	76.0	2.3	30.0
1990	4.3	3.7	5.6	3.5	3.8	-0.1	*(0.8)*	*(-0.9)*	2.0	1.9	0.5	76.5	2.2	31.2
1991	4.5	3.6	3.3	3.1	3.4	-0.2	*(0.8)*	*(-1.0)*	1.8	1.7	0.5	77.1	2.2	30.9
1992	2.7	1.7	0.8	2.7	2.7	-0.3	*(0.7)*	*(-1.0)*	1.5	1.5	0.3	77.7	2.3	29.4
1993	0.5	-0.2	0.2	2.3	2.1	-0.5	*(0.5)*	*(-1.0)*	1.3	1.3	0.2	78.3	2.4	28.1
1994	-0.5	-1.0	0.9	1.9	1.7	-0.6	*(0.2)*	*(-0.8)*	1.1	1.1	0.0	78.8	2.7	27.2
1995	-0.3	-0.8	1.9	1.6	1.7	-0.4	*(0.3)*	*(-0.7)*	1.0	1.0	0.3	79.2	3.0	27.0
1996	1.0	0.4	2.6	1.4	1.4	-0.6	*(-0.1)*	*(-0.6)*	1.1	0.9	-0.1	79.5	3.3	27.8
1997	1.4	0.8	1.6	1.2	1.2	-0.7	*(-0.2)*	*(-0.5)*	1.0	0.9	-0.1	79.6	3.5	27.4
1998	-1.7	-2.0	-2.0	1.0	0.7	-0.9	*(-0.4)*	*(-0.5)*	0.7	0.9	-0.1	79.6	3.9	25.3
1999	-2.8	-2.8	-0.1	0.9	0.7	-0.9	*(-0.5)*	*(-0.5)*	0.6	1.0	-0.2	79.5	4.3	24.9
2000	-0.9	-0.6	2.9	0.9	0.6	-1.0	*(-0.6)*	*(-0.4)*	0.6	1.0	-0.4	79.3	4.5	25.0
2001	-1.6	-1.2	0.2	0.9	0.8	-0.8	*(-0.5)*	*(-0.3)*	0.5	1.1	-0.3	79.1	4.7	24.6
2002	-2.3	-1.6	0.3	0.9	0.6	-0.8	*(-0.5)*	*(-0.3)*	0.3	1.1	-0.5	78.9	4.8	23.2
2003	-1.8	-1.0	1.4	0.9	0.9	-0.5	*(-0.2)*	*(-0.2)*	0.2	1.1	-0.4	78.9	4.8	22.9
2004	0.0	0.6	2.7	0.9	1.1	-0.2	*(-0.0)*	*(-0.2)*	0.2	1.1	-0.4	79.1	4.6	23.0
2005	1.1	1.5	1.9	0.8	1.0	-0.3	*(-0.1)*	*(-0.2)*	0.3	1.1	-0.8	79.4	4.5	23.5
2006	2.5	2.5	2.0	0.7	1.0	-0.2	*(-0.1)*	*(-0.1)*	0.3	1.0	-0.8	79.8	4.4	23.3
2007	4.3	4.0	2.4	0.6	0.9	-0.3	*(-0.2)*	*(-0.1)*	0.2	0.9	-0.9	80.3	4.3	22.9
2008	2.6	1.8	-1.2	0.4	1.0	-0.1	*(-0.0)*	*(-0.1)*	0.2	0.9	-0.4	80.7	4.4	22.1
2009	-3.0	-3.8	-5.2	0.3	0.3	-0.5	*(-0.4)*	*(-0.1)*	-0.1	0.9	-0.7	81.0	4.7	18.9
2010	-1.2	-2.1	2.1	0.2	0.3	-0.5	*(-0.5)*	*(-0.0)*	-0.1	0.9	-0.8	81.2	4.9	18.5
2011	0.1	-1.1	1.5	0.2	0.5	-0.4	*(-0.4)*	*(-0.0)*	-0.1	1.0	-0.6	81.4	5.0	18.9
2012				0.2	0.2	-0.8	*(-0.8)*	*(-0.0)*	0.0	1.0	-1.3	81.5	5.1	19.0
2013				0.2	0.2	-0.9	*(-0.9)*	*(-0.0)*	0.0	1.1	-1.4	81.6	5.2	19.2
2014				0.2	0.3	-0.8	*(-0.8)*	*(0.0)*	0.0	1.1	-1.3	81.6	5.2	19.4
Periods	**Period Averages**													
1981-1985	-1.8	-1.7	4.3	4.2	4.0	0.4	(0.5)	(-0.1)	1.6	2.0	0.9	76.1	2.2	25.1
1986-1990	0.6	0.7	5.0	4.0	4.2	0.2	(0.7)	(-0.5)	1.7	2.1	0.9	75.9	2.4	28.3
1991-1995	1.4	0.7	1.4	2.3	2.3	-0.4	(0.5)	(-0.9)	1.4	1.3	0.3	78.2	2.5	28.5
1996-2000	-0.6	-0.8	1.0	1.1	0.9	-0.8	(-0.3)	(-0.5)	0.8	1.0	-0.2	79.5	3.9	26.1
2001-2005	-0.9	-0.3	1.3	0.9	0.9	-0.5	(-0.3)	(-0.2)	0.3	1.1	-0.5	79.1	4.7	23.4
2006-2010	1.0	0.5	0.0	0.4	0.7	-0.3	(-0.2)	(-0.1)	0.1	0.9	-0.7	80.6	4.5	21.1
2011-2014				0.2	0.3	-0.7	(-0.7)	(-0.0)	0.0	1.0	-1.1	81.5	5.1	19.1

Japan

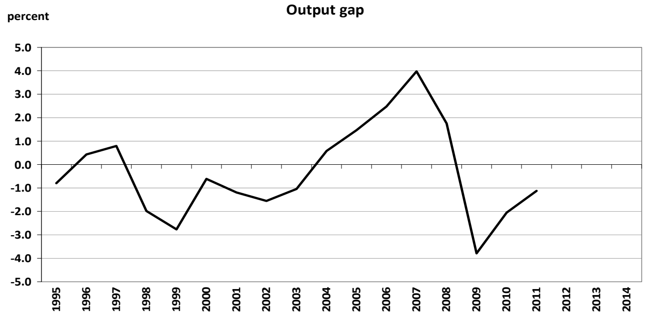
Output Growth



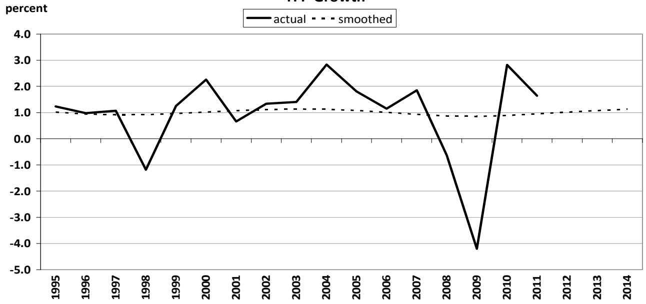
Contributions to Potential Output



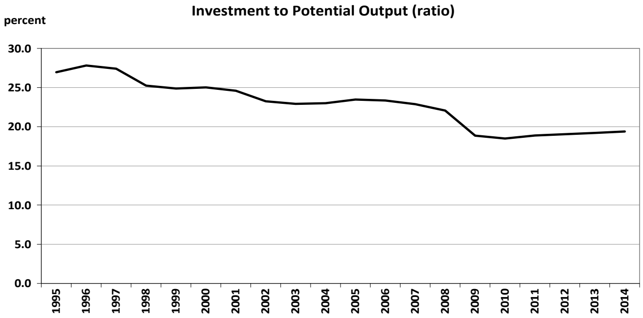
Output gap



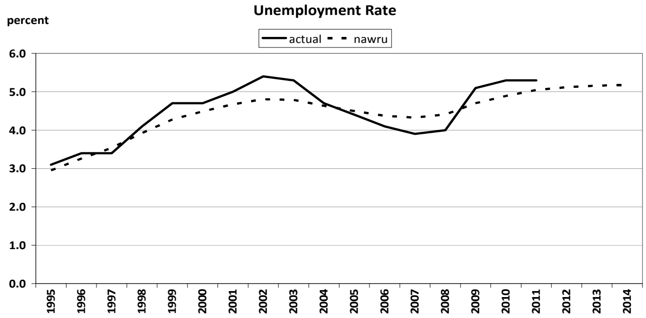
TFP Growth



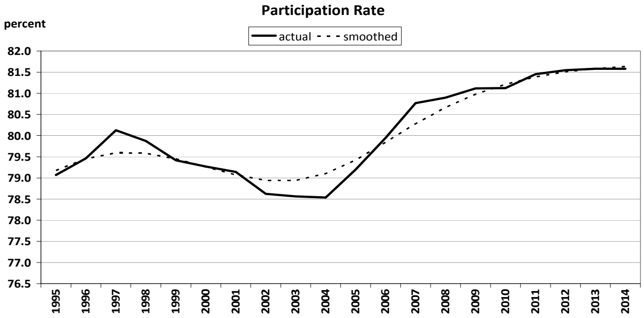
Investment to Potential Output (ratio)



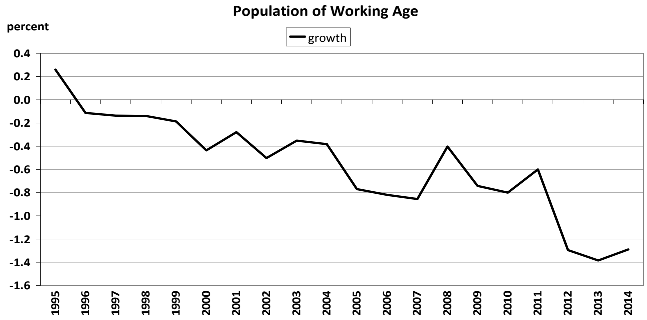
Unemployment Rate



Participation Rate



Population of Working Age



Employment

Hours Worked per Employee