On the reliability of international organisations' estimates of the output gap

Macroeconomic analyses are often based on a decomposition of aggregate activity into potential (or trend) output and a cyclical component, the output gap. As an economy's potential output is unknown, estimates of this gap, which can assume positive or negative values, are, in practice, associated with a high degree of uncertainty. In the past, simple as well as more complex statistical procedures have proven fairly unreliable as a way of deriving trend output at the current end. Later revisions were often as large as the previously identified gap itself. This was attributable less to corrections to the underlying data than to the changing assessment of the cyclical position over time.

If, in a bid to evaluate estimates of the output gaps for important industrial countries, one compares International Monetary Fund (IMF) and Organisation for Economic Cooperation and Development (OECD) estimates as given in their regular publications from the spring of 1999 onwards with the appropriate real-time measures as derived using a simple statistical procedure, it becomes evident that the estimates provided by the international institutions are by no means more reliable. There are large revisions, and the published output gaps change their sign relatively frequently. Unlike with the results of simple filter methods, the need for corrections does not appear to be limited to estimates at the current end where there has been a turnaround in economic momentum. In fact, output gaps for more distant years are frequently also revised. This can mainly be explained by reassessments of an economy's potential growth path.

In addition, there is some evidence to suggest that international organisations' estimates of the output gap for the years just ended are frequently initially too unfavourable, ie too deep in, or too close to, negative territory for the selected circle of countries and period. In the following rounds, these estimates have generally been revised up. Consequently, major economies' potential was probably considerably overestimated during the boom at the turn of the millennium and in the years immediately preceding the global financial crisis. The subsequent drop in output was initially interpreted as a cyclical phenomenon. It was not until recoveries proved weak that it appears gradually to have become apparent that the preceding upwards movements were unsustainable.

Given past experience, it cannot be ruled out that the IMF and the OECD will, in the future, correct their information on the output gaps at the current end and going further back. Given this uncertainty, such estimates have to be treated with caution in economic policy practice, say when analysing cyclically adjusted fiscal deficits, or in a monetary policy context.

Basic problem with the output gap

Actual economic growth a combination of potential growth and cyclical factors

For macroeconomic analyses and models, aggregate activity as measured by real gross domestic product (GDP) is often broken down into potential output and a cyclical component. The latter measures the (positive or negative) gap between actual and potential economic performance and is also called the output gap. It reflects cyclical ups and downs and indicates, amongst other things, whether an economy is experiencing demand-side upwards or downwards pressure on prices. Potential output is generally defined as that level of activity that occurs when capacity utilisation in the economy as a whole is "normal". Capacity is, in turn, dictated by supply-side determinants of longer-term growth. These include the economy's supply of labour and capital equipment. Technology, the institutional framework and structural policy are also important.

Unlike the now wide-spread interpretation of potential output as the level of activity that prevails under normal capacity utilisation, economists used to interpret it as full-employment output in a Keynesian context.[1] In their view, the question was how high aggregate demand must be in order to close the gap between maximum possible and actual output, which always veers towards underutilisation. Factors such as demographic developments, which determine full-employment output, may also, via investment demand, impact the level of underemployment in the longer term. This relationship is at the centre of the Keynesian theory of "secular stagnation", in which interest has recently reawakened (see box on pages 16 to 19).

Estimate of output gap as an unobservable variable

As potential output and the output gap are the result of a notional decomposition of actually measured economic output,[2] they cannot be observed directly. In the national accounts, the official statistics estimate only actual output, not potential output. The output gap can therefore only be approximated using suitable procedures based on the available data. A wide range of methods are available, however.[3] Because potential output can be understood as the economy's output adjusted for cyclical fluctuations (or trend output), an obvious approach is to use simple statistical procedures to smooth real GDP.[4] In particular, this includes the Hodrick-Prescott filter (HP filter), which is often used in practice.[5] Alternatively, more complex econometric models can also be used to determine potential output and the output gap. Here, the production function approach, which most international organisations, including the

1 See A Okun, Potential GNP: Its Measurement and Significance, American Statistical Association, Proceedings of the Business and Economics Statistics Section 1962, pp 98-103; and T Congdon (2008), Two Concepts of the Output Gap, World Economics, Vol 9, No 1, pp 147-175.
2 Over and above the outlined definitions, specific models are associated with alternative definitions of potential output. New Keynesian models, for instance, regularly take it to be the level of activity that would occur where prices are flexible. See, eg, M T Kiley (2013), Output Gaps, Journal of Macroeconomics, Vol 37, pp 1-18.
3 See, for instance, Deutsche Bundesbank, The development of production potential in Germany, Monthly Report, March 2003, pp 41-52.
4 Estimating an economy's production possibilities as a measure of its potential output includes analysing available capacity. By contrast, simple statistical procedures, which take no additional economic information into account, only determine a time series' mathematical trend. We will, in this article, not differentiate strictly between "potential" and "trend" and the associated output gaps.
5 When extracting a time series' trend component, the HP filter, according to a specified smoothing parameter, balances minimising cyclical fluctuations against minimising changes in the growth rate of the trend component. See R J Hodrick and E C Prescott (1997), Postwar U. S. Business Cycles: An Empirical Investigation, Journal of Money, Credit and Banking, Vol 29, No 1, pp 1-16.

OECD, currently use, plays a prominent role.[6] It ultimately includes an analysis of the available capacity in the economy as a whole and its supply-side determinants. This is because a production function describes how the quantities of labour and capital employed and the technology used make up aggregate output.[7] To derive the respective potential growth path from actual developments in labour input or what is known as total factor productivity (as a measure of technology), simple cyclical adjustment procedures can again be used, such as the HP filter, although at a different level than when directly smoothing real GDP.

Large discrepancies between estimates of the output gap at the current end

Concrete estimates of the output gap depend on which procedure is chosen. This is clear from a comparison of the IMF's and OECD's autumn 2013 data on the output gap in the G7 economies with the estimate resulting from an HP filter.[8] All three procedures appear to yield a similar cyclical pattern across this group of countries – with peaks and troughs at virtually identical points in time. In addition, no major discrepancies are noticeable in terms of the size of the cyclical output component for the decades immediately before and after the turn of the millennium. However, the data differ widely, especially at the current end.[9] For instance, the IMF last autumn reported that the seven largest advanced economies experienced overall capacity underutilisation of 3% in 2012, while the output gap in this group of countries had already been closed according to the HP filter. The OECD data imply capacity underutilisation of 2% for this group of countries as a whole, although this masks discrepancies, some large, as compared to the IMF estimates for individual industrialised nations. For instance, the Fund expects much larger gaps for the United States (-4¼%) and Japan (-2¼%) than the OECD (-2½% and -1% respectively), while the OECD, in turn, forecasts a greater shortfall in aggregate demand for Italy (-4½% versus -3½%).

Stable inflation rates after the global recession

While concerns that inflation is easing have recently been voiced in some industrialised countries, it is rather surprising, given the persistently large negative output gaps being reported by international organisations, that inflation rates have remained in positive territory fairly consistently in recent years. Based on a Phillips curve, attempts to explain this circumstance have focused, first, on the fact that inflation expectations are firmly anchored and, second, on the weaker impact of cyclical factors on inflation over time, as explained in an-

6 While the OECD generally uses a production function approach in connection with a Phillips curve, which has been described by Giorno et al (1995), Beffy et al (2006) and Johansson et al (2013), the IMF has not committed to using one specific procedure. In general, estimates are, however, also likely to have been based on such a method in the past. In addition, the Fund appears recently increasingly to have used a multivariate filter procedure developed by Benes et al (2010), which is based on various cyclical correlations and therefore also takes into consideration additional information on the state of the economy. See C Giorno, P Richardson, D Roseveare and P van den Noord (1995), Estimating Potential Output, Output Gaps and Structural Budget Balances, OECD, Economic Studies, No 24, pp 167-209; P Beffy, P Ollivaud, P Richardson and F Sédillot (2006), New OECD Methods for Supply-side and Medium-term Assessments: A Capital Services Approach, OECD Economics Department, Working Paper No 482; A Johansson, Y Guillemette, F Murtin, D Turner, G Nicoletti, C de la Maisonneuve, P Bagnoli, G Bousquet and F Spinelli (2013), Long-Term Growth Scenarios, OECD Economics Department, Working Paper No 1000; P R De Masi (1997), IMF Estimates of Potential Output: Theory and Practice, IMF, Working Paper No WP/97/177; J Benes, K Clinton, R Garcia-Saltos, D Laxton, P Manchev and T Matheson (2010), Estimating Potential Output with a Multivariate Filter, IMF, Working Paper No WP/10/285; and J-P Cotis, J Elmeskov and A Mourougane (2005), Estimates of Potential Output, Benefits and Pitfalls from a Policy Perspective, in: L Reichlin (ed), Euro Area Business Cycles: Stylized Facts and Measurement Issues, CEPR, pp 35-60.

7 See Deutsche Bundesbank, Potential growth of the German economy – medium-term outlook against the backdrop of demographic strains, Monthly Report, April 2012, pp 13-28.

8 The G7 countries are the United States, Japan, Germany, France, the United Kingdom, Italy and Canada. The latest data refer to the World Economic Outlook (WEO) of October 2013 and the Economic Outlook (EO) No 94 (of November 2013). As recommended by Ravn and Uhlig (2002), a smoothing parameter for the HP filter of 6.25 is chosen here and throughout. The underlying time series for (actual) real GDP are taken from the IMF's WEO database, as a logarithm and extrapolated using the average growth rate of the past ten years. See M O Ravn and H Uhlig (2002), On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations, Review of Economics and Statistics, Vol 84, No 2, pp 371-380.

9 See P Gerlach, The Global Output Gap: Measurement Issues and Regional Disparities, BIS, Quarterly Review, June 2011, pp 29-37.

Secular stagnation and economic growth

The theory of "secular stagnation", posited in particular by Alvin Hansen in the late 1930s, is based on the Keynesian notion of market equilibrium with underemployment. From this perspective, the key question is how high aggregate demand in the economy has to be in order to close an output gap tending consistently towards capacity underutilisation. In this scenario, factors which determine the path of potential output may also influence the level of aggregate demand in the economy via investment demand, and affect the level of underemployment over the longer term. According to Hansen, there is a connection between a slowdown in potential output growth and increasing underemployment.[1] Not least, a decline in population growth will slow the expansion in investment demand and, as a result, an economy's capacity utilisation will fall further.

The background to this theory is the fact that the Great Depression (1929 to 1933) in the United States occurred in a period of declining population growth. An examination of the unemployment rate and the year-on-year rate of change in the resident population (of working age) in the United States does indeed appear to reveal a negative correlation between the two variables in the first half of the twentieth century. The US economy's slide into renewed recession in 1937 is likely to have given further support at the time to the belief that the sharp increase in underemployment at the beginning of the decade might be a "secular" problem, ie persistent, and not just cyclical. However, in the second half of the twentieth century, there is no noticeable correlation between population growth and the unemployment rate. The distinct drop in the unemployment rate in recent years, at a time of only moderate expansion in aggregate output, could in fact be an indication that demographic change is assisting the current labour market recovery rather than hindering it.[2]

Of late there has again been increased discussion of a possible connection between a slowdown in potential growth, especially as a result of demographic change, and persistent slack in the economy.[3] The hypothesis has been proposed that such a situation may arise in association with the zero bound on nominal interest rates.[4] To illustrate this, a distinction is first drawn between various concepts of the real interest rate.[5] The "natural" or "neutral" rate of interest is defined as that real interest rate at which the output gap will be closed in the medium term. Supply-side and demand-side shocks may cause it to fluctuate around the real interest rate which prevails in the economy's long-term equilibrium

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1 Ultimately, the economy would enter a state of high underemployment and stagnating potential output. According to Higgins (1950), however, Hansen's use of the term "secular stagnation" referred to the stage of declining potential growth and rising underemployment. See A Hansen (1939), Economic Progress and Declining Population Growth, American Economic Review, Vol 29, pp 1-15, reprinted in Population and Development Review (2004), Vol 30, pp 329-342; B Higgins (1950), The Concept of Secular Stagnation, American Economic Review, Vol 40, No 1, pp 160-166; and A Scaperlanda (1977), Hansen's Secular Stagnation Thesis Once Again, Journal of Economic Issues, Vol 11, No 2, pp 223-243.

2 See Deutsche Bundesbank, The decline in labour force participation in the USA, Monthly Report, May 2012, pp 19-21.

3 Some have interpreted the newly formulated theory of "secular stagnation" as operating in a different direction, whereby persistent capacity underutilisation in an economy may permanently flatten that economy's potential growth path. Although temporary weakness in investment delays growth in the capital stock and a lengthy period of high underutilisation may also bring about a lasting reduction in the level of potential output, particularly through an increase in structural unemployment, ultimately, longer-term growth in the economy's overall productive capacity remains unaffected. See, for example, D Reifschneider, W Wascher and D Wilcox (2013), Aggregate Supply in the United States: Recent Developments and Implications for the Conduct of Monetary Policy, Federal Reserve Board, Discussion Paper.

4 See L H Summers, speech on 8 November 2013 at the IMF Fourteenth Annual Research Conference, at http://larrysummers.com/imf-fourteenth-annual-research-conference-in-honor-of-stanley-fischer/.

5 See, for example, T Bernhardsen and K Gerdrup (2007), The Neutral Real Interest Rate, Norges Bank, Economic Bulletin, Vol 78, pp 52-64.

state. This long-term equilibrium real interest rate is, in turn, determined by fundamental economic factors such as potential output growth and saving behaviour.

The central bank can set the (short-term) nominal interest rate and thereby influence the actual real interest rate in a situation of price rigidity. This gives monetary policymakers a stabilising role in the short term. If the actual real interest rate is below the natural rate of interest, then monetary policy has an expansionary effect and, if there is a negative output gap, helps to close it and to ease the downward pressure on prices. However, if the natural rate of interest is negative, it is possible that, with given inflation expectations, the central bank will be unable to cut the real interest rate to a sufficient extent because of the zero bound on nominal interest rates. If the natural rate of interest has slid into negative territory on a lasting basis, ie if the long-term equilibrium real interest rate has similarly altered, then the economy may be caught in a permanent scenario of underutilised capacity.

The possibility of the natural rate of interest slipping temporarily below zero and the implications of this have been discussed by a number of economists within the framework of state-of-the-art New Keynesian models.[6] However, it is difficult for such models to capture a shift in the long-term equilibrium real interest rate because this is ultimately determined by the rate of time preference for a representative economic agent.[7] Eggertsson and Mehrotra (2014) recently set out a solution for this.[8] An unequal distribution of income over an economic agent's life cycle gives rise to supply of or demand for loans at different stages of life. As Samuelson (1958) explained, when overlapping generations of economic agents are brought into the picture, the long-term equilibrium real interest rate brings the supply of and demand for loans between the generations into balance.[9] Thus, shocks to fundamental variables can drive the long-term equilibrium real interest rate below zero and thereby reduce output below its potential level on a lasting basis.[10] However, the model proposed by Eggertsson and Mehrotra (2014) does not capture the possibility of savings in the economy as

Unemployment rate and population growth in the United States since 1902

%, annual data

Source: Haver Analytics. **1** Year-on-year growth in resident population of working age (aged 15 to 64). **2** Number of unemployed as a percentage of the labour force. **3** Not including 1918 and 1919.

Deutsche Bundesbank

6 In New Keynesian models, price rigidity means that even purely monetary shocks have an impact on the real economy in the short term. In this, the natural rate of interest and the level of potential output are regularly defined in terms of the level of activity in a situation of flexible prices. The economic policy implications of a temporarily negative natural rate of interest with a binding lower limit for the nominal interest rate (liquidity trap) have been investigated within the framework of a simple New Keynesian model by, for example, Werning (2011) and Cochrane (2013). See I Werning (2011), Managing a Liquidity Trap: Monetary and Fiscal Policy, NBER, Working Paper No 17344; and J H Cochrane (2013), The New-Keynesian Liquidity Trap, NBER, Working Paper No 19476.

7 Schmitt-Grohé and Uribe (2013) have formulated a model in which a confidence shock and self-fulfilling expectations create a permanent liquidity trap and underemployment. See S Schmitt-Grohé and M Uribe (2013), The Making of a Great Contraction with a Liquidity Trap and a Jobless Recovery, NBER, Working Paper No 18544.

8 See G Eggertsson and N Mehrotra (2014), A Model of Secular Stagnation, Brown University, Discussion Paper.

9 See P A Samuelson (1958), An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money, Journal of Political Economy, Vol 66, No 6, pp 467-482.

10 For example, an exogenous reduction of the borrowing limit for young people (deleveraging) could cause the real interest rate to fall – and not just in the short term but for a relatively long period – because the supply of credit from this generation at a later stage in life is increased. See G Eggertsson and N Mehrotra (2014), op cit.

a whole in the form of physical capital. Yet in terms of long-term economic growth, decisions about capital investment and capital stock are likely to be of key importance, particularly in connection with overlapping generations.

The neoclassical theory of growth offers a consistent model framework in which to investigate the connection between the long-term equilibrium real interest rate and the underlying rate of expansion in an economy. Within this theory, the profit-maximising behaviour of enterprises in a scenario of perfect competition causes the marginal productivity of capital to match its factor price. A negative (net) real interest rate implies that the rate of depreciation exceeds the positive marginal productivity of capital. However, if that were the case in an economy without population growth or technological advance, the capital stock would be inefficiently large owing to an excess of previous capital investment, meaning that consumption opportunities could still be expanded even in the long term through a reduction in capital. But if intertemporal optimisation in a representative household is factored into the equation, then such a state of affairs can hardly constitute an equilibrium. Ultimately the equilibrium real interest rate in a stationary economy will correspond to households' positive rate of time preference. This means that economic agents with a predominant preference for current consumption need to be compensated in the form of a positive real interest rate for forgoing current consumption in order to maintain the capital stock.

If long-term growth in the economy through population growth and technological advance is now added in, the equilibrium real interest rate in a neoclassical world is higher than the increase in potential output.[11] There may be deviation from this rule and thus accumulation of an inefficiently large capital stock if, in models with overlapping generations, capital formation represents the only means of making provision for the future.[12] However, factoring in a non-reproducible production factor, ie land, would prevent what is called dynamic inefficiency even in the above scenario, because arbitrage would mean that the productivity of capital could not fall below the positive rate of return on land.[13] In addition, an inefficiently large capital stock would imply that capital investment exceeds income from capital. However, that does not appear to be borne out by empirical findings.[14]

A negative equilibrium real interest rate would nonetheless be conceivable, without breaching the efficiency condition, if the potential output of an economy shrank to a sufficient extent.[15] Therefore, the empirical question as to long-term growth prospects in the industrial countries remains. Although the expansion of potential output in the United States is likely to have weakened noticeably in recent years, not least owing to demographic change, it has not come to a standstill.[16] The expansion in the US popu-

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11 See, for example, D Romer (2011), Advanced Macroeconomics, McGraw-Hill, 4th edition.
12 See P A Diamond (1965), National Debt in a Neoclassical Growth Model, American Economic Review, Vol 55, No 5, pp 1126-1150; C C von Weizsäcker, Der Vorsorge-Albtraum, Wirtschaftsdienst, special edition 2013, pp 7-15; and C C von Weizsäcker (2014), Public Debt and Price Stability, German Economic Review, Vol 15, pp 42-61.
13 See S Homburg (1991), Interest and Growth in an Economy with Land, Canadian Journal of Economics, Vol 24, No 2, pp 450-459; and S Homburg (2014), Overaccumulation, Public Debt, and the Importance of Land, Leibniz Universität Hannover, Discussion Paper No 525.
14 In empirical investigations into the theory of dynamic inefficiency resulting from the gap between interest rates and growth rates, it needs to be borne in mind that investments in physical capital entail risks, which means that ultimately the result does not hinge on the interest rate on risk-free investments, which is often the focus of abstract models and public debate. See A B Abel, N G Mankiw, L H Summers and R J Zeckhauser (1989), Assessing Dynamic Efficiency: Theory and Evidence, Review of Economic Studies, Vol 56, No 1, pp 1-19; and S Homburg (2014), op cit.
15 See S Homburg (2014), op cit.
16 See Deutsche Bundesbank, The US economy in the current economic upturn, Monthly Report, April 2013, pp 15-37.

lation of working age has merely become sluggish, it has not turned into a lasting contraction. In addition, those who have been expressing well-founded doubts as to the continuation of the high levels of US productivity growth observed in the past point only to slower technological advance, not technological decay.[17] Even in the case of Japan, where the working-age population has been shrinking for some time, estimates generally continue to indicate an upward trajectory for potential output.[18]

Overall, the natural rate of interest and the long-term equilibrium real interest rate can no more readily be observed than potential output or the output gap; estimates of these variables come with a high degree of uncertainty. As potential output is presumably still trending upwards, the long-term equilibrium real interest rate in major advanced economies is likely to be positive, even if it has fallen as a result of demographic change. Therefore, the argument that developed economies may currently be in a state of secular stagnation probably lacks empirical significance.

17 See R J Gordon (2012), Is U. S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds, NBER, Working Paper No 18315; and R J Gordon (2014), The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections, NBER, Working Paper No 19895.

18 Even in the context of continued positive potential growth, doubt has been cast on the significance of a lasting negative equilibrium real interest rate for underutilisation of capacity in the Japanese economy. See K Nishizaki, T Sekine and Y Ueno (2012), Chronic Deflation in Japan, Bank of Japan, Working Paper No 12-E-6. Ikeda and Saito (2012) use simulations within the framework of a dynamic general equilibrium model to show that the fall in the ratio of the working-age population to the total population in recent years has resulted in a marked fall in the natural rate of interest in Japan. However, fluctuations in technological advance have proved more significant in this connection. See D Ikeda and M Saito (2012), The Effects of Demographic Changes on the Real Interest Rate in Japan, Bank of Japan, Working Paper No 12-E-3.

other article in this report (see pages 61 to 76).[10] Moreover, large discrepancies between estimates of the output gap suggest that the underutilisation of overall capacity in the economy may not be as pronounced as is frequently assumed. The measure of the output gap chosen also has consequences for the observed sensitivity of the rate of inflation to economic ups and downs. When estimating the Phillips curve for the euro area and individual member states, this sensitivity tends to be weaker if the large output gaps published by the IMF are used. By contrast, cyclical sensitivity proves higher if the smaller output gaps determined with the help of the HP filter are used (see box on pages 21 to 24).

Estimates' susceptibility to revision as yardstick

As the "true" output gap cannot be known, it is impossible to decide which estimate most closely approximates it. One possible indication of the reliability of such information may be to analyse how susceptible it is to revision at the current end. The underlying idea is that revisions reflect additional information and result in a "final" figure. Where initial estimates deviate relatively little from the "final" figures, they are considered fairly reliable.

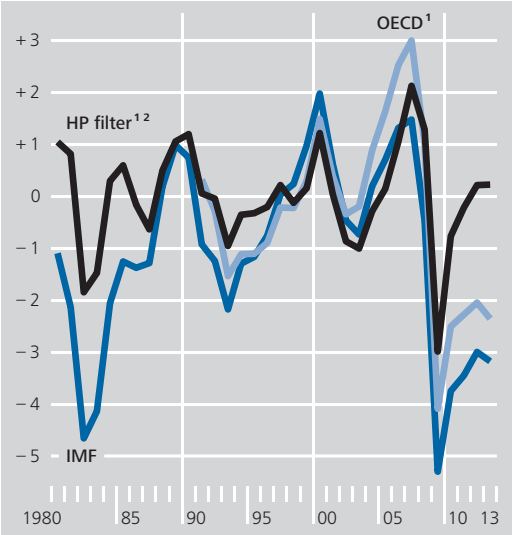
Possible reasons for revisions

In general, revisions to estimated output gaps may have various causes; sometimes, they are inevitable. For instance, the underlying data material may simply have been corrected, ie, for simple univariate procedures, the time series on real GDP. Moreover, the need for revisions is obvious given that the future outlook is key to determining the current cyclical position. If expectations prove wrong, the assessment of the past years also changes retrospectively. For instance, a situation is conceivable in which a cyclical peak with a positive output gap becomes apparent only as a result of a subsequent, unexpected downturn. Conversely, after

10 See also IMF, The Dog That Didn't Bark: Has Inflation Been Muzzled Or Was It Just Sleeping?, World Economic Outlook, April 2013, pp 79-95.

Autumn 2013 estimates of the output gap in the G7 countries*

As a percentage of potential output



Sources: IMF World Economic Outlook (WEO) October 2013, OECD Economic Outlook No 94 (November 2013) and Bundesbank calculations. Data for 2013 are projections. * United States, Japan, Germany, France, United Kingdom, Italy and Canada. **1** Estimates for individual countries have been aggregated using nominal GDP weights (on US dollar basis). **2** Hodrick-Prescott filter with smoothing parameter of 6.25 applied to time series of real GDP (according to WEO), which were extrapolated based on the average growth rates of the last ten years.

Deutsche Bundesbank

a recession the question arises as to whether an economy can return to its previous path of activity. It might be possible to identify output losses as permanent only after a rapid recovery process fails to materialise for some time, making it necessary to retract the initial assessment that there is a large degree of underutilisation. Similarly, when applying a filter procedure, the assessment of the underlying trend may also change as further developments come to light as compared to the previous assessment that was made based on incomplete information. The trend is especially likely to be adjusted at a later date near cyclical highs or lows (that are determined *ex post*). This end-point issue is frequently described as the weakness of the HP filter.[11] Using more complex models to determine potential output, the model's susceptibility for revision itself represents another source of corrections to the estimated cyclical output component.

Real-time estimates of the output gap generally fairly unreliable at the current end

Orphanides and van Norden (2002) have examined the reliability of estimates of the output gap at the current end for the US economy, which they constructed based on real-time data using simple statistical trend extraction methods such as the HP filter but also more complex models. These more complex models included additional economic information. On balance, the authors concluded that the real-time estimates produced by the various procedures were generally not very reliable. The subsequent revisions were frequently of the same order of magnitude as the initial estimates of the gap. This was due only in small part to later corrections to the underlying data. The stubborn problem of reliably distinguishing trend and cycle at the current end proved more decisive. This ultimately reflects the fact that future economic developments are unknown. After all, the more complex procedures did not outperform equivalent univariate methods. The information advantage of including additional variables has to be weighed against the fact that the greater complexity also entails the possibility of additional revisions.[12]

Review of IMF and OECD estimates

Analysis of IMF and OECD estimates for historical output gaps

The reliability of the IMF and OECD data on the annual output gaps in the G7 economies since the spring 1999 World Economic Outlook (WEO) and Economic Outlook (EO) respectively

11 It is caused in the main by the symmetrical construction of smoothing, in which both past and future data are taken into consideration. At the current end, there is no "punishment" for a later reversal of a change in trend when weighing the deviation from the trend against the smoothness of this trend. As a result, the extracted trend follows temporary fluctuations more closely at the current end than in the middle of the observation period. See, for instance, P St-Amant and S van Norden (1997), Measurement of the Output Gap: A Discussion of Recent Research at the Bank of Canada, Bank of Canada, Technical Report, No 79.

12 See A Orphanides and S van Norden (2002), The Unreliability of Output-Gap Estimates in Real Time, Review of Economics and Statistics, Vol 84, No 4, pp 569-583.

Cyclical sensitivity of the inflation rate in the euro area and in selected euro-area countries depending on the output gap estimate

Even before the global recession of 2008-09, various empirical studies found that in industrial countries the cyclical sensitivity of consumer prices had been declining since the mid-1980s. Analysts put forward the increasing importance of cross-border price relationships in the wake of globalisation, a better anchoring of inflation expectations and the special environment of low inflation rates as possible explanations for this decline.[1] The comparatively weak response of the core rates in particular (eg based on the (harmonised) index of consumer prices excluding energy and unprocessed food) to the economic slump in 2008-09 initially provided a further indication of such a decline.[2] However, the recent marked decline in inflation has led to speculation in various quarters that the connection between price developments and cyclical developments may have intensified again of late, at least in some euro-area countries.[3]

The analytical concept often used in this context is the Phillips curve. It was originally based on the empirical observation that wage growth and the unemployment rate are negatively correlated.[4] This approach was then extended by additionally mapping the relationship between consumer price inflation and unemployment. In a further step, the macroeconomic output gap was introduced as the indicator for the cyclical position in place of the unemployment rate. During booms and when levels of capacity utilisation are high, the observed inflation rate is indeed relatively high, whereas it is fairly low in periods of recession. Using the Phillips curve model, the output gap thus serves as an indicator for price trend estimation which can also be forward-looking.

However, in this context it is important to note that estimated capacity utilisation can vary considerably depending on the procedure used to calculate the output gap. In this analysis, we thus examine the impact that the choice of procedure has on the econometric estimates of the cyclical sensitivity of inflation rates both for the euro area as a whole and for selected euro-area countries. We use data on output gaps published in the IMF's October 2013 World Economic Outlook (WEO) and deviations of real GDP from its trend extracted from the GDP time series using the Hodrick-Prescott filter (HP filter) – a purely statistical method.[5] The current end is of particular interest as it is here that the results for the output gap are particularly divergent. For instance, for both the euro area as a whole and for France there is a divergence of two percentage points between the results from the two procedures; in the case of Italy, it is even over three percentage points. By contrast, Germany's capacity utilisation is virtually identical in both procedures.

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1 See N Pain, I Koske and M Sollie (2006), Globalisation and Inflation in the OECD Economies, OECD Economics Department, Discussion Paper, No 524; IMF, How has Globalization Affected Inflation?, World Economic Outlook, April 2006, pp 97-134; as well as J B Taylor (2000), Low Inflation, Pass-Through and the Pricing Power of Firms, European Economic Review, Vol 44, pp 1389-1408.

2 See D Moccero, S Watanabe, B Cournède (2011), What Drives Inflation in the Major OECD Economies, OECD Economics Department, Discussion Paper, No 854; ECB, The Development of Prices and Costs During the 2008-09 Recession, Monthly Bulletin, April 2012, pp 71-85; as well as IMF, The Dog that Didn't Bark: Has Inflation Been Muzzled or Was It Just Sleeping?, World Economic Outlook, April 2013, pp 79-95.

3 See European Commission (2014), Analysing Current Disinflationary Trends in the Euro Area, European Economic Forecast, pp 39-41; as well as National Bank of Belgium (2013), What Inflation Developments Reveal About the Phillips Curve: Implications for Monetary Policy, Economic Review, pp 67-76.

4 See A W Phillips (1958), The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom 1861-1957, Economica, Vol 25, pp 283-299.

5 To reduce the HP filter's endpoint bias, the quarterly profile of real GDP for 2014 and 2015 was extrapolated using the European Commission's latest forecast. The HP filter was given a smoothing parameter of 1,600, which tends to be the default value for quarterly data.

Cyclical sensitivity of inflation rates in the period from 1996 to 2009 depending on the output gap*

Item	Euro area				Germany				France				Italy			
	Headline rate[1]		Core rate[2]		Headline rate[1]		Core rate[2]		Headline rate[1]		Core rate[2]		Headline rate[1]		Core rate[2]	
	Output gap according to filter technique															
π^e	0.64	(4.5)	0.27	(3.0)	0.68	(9.8)	0.32	(3.2)	0.70	(3.9)	0.29	(6.6)	0.62	(3.5)	1.11	(20.1)
π_{t-1}	0.22	(1.6)	0.64	(5.7)	–	–	0.45	(3.4)	0.18	(1.3)	0.62	(10.2)	0.36	(2.3)	–	–
HP gap	0.28	(2.3)	0.11	(2.9)	0.39	(5.4)	0.12	(2.2)	0.37	(2.5)	0.09	(1.9)	0.28	(2.6)	0.17	(2.5)
Commodity prices	0.05	(2.4)	–	–	0.09	(3.3)	–	–	0.02	(1.0)	–	–	0.06	(3.9)	–	–
R^2	0.52	–	0.51	–	0.33	–	0.16	–	0.32	–	0.38	–	0.39	–	0.18	–
J-stat (prob)	0.36	–	0.10	–	0.07	–	0.24	–	0.63	–	0.13	–	0.26	–	0.34	–
	Output gap according to IMF forecast															
π^e	0.71	(4.7)	0.29	(3.2)	0.73	(10.2)	0.38	(3.4)	0.59	(3.5)	0.26	(4.4)	0.57	(3.6)	1.05	(24.4)
π_{t-1}	0.17	(1.3)	0.61	(5.4)	–	–	0.41	(3.0)	0.21	(1.3)	0.58	(8.3)	0.33	(2.3)	–	–
IMF gap	0.30	(3.1)	0.14	(3.5)	0.42	(7.1)	0.16	(2.7)	0.22	(2.7)	0.16	(4.0)	0.28	(3.2)	0.17	(2.4)
Commodity prices	0.04	(2.3)	–	–	0.09	(3.4)	–	–	0.03	(1.6)	–	–	0.05	(3.9)	–	–
R^2	0.49	–	0.52	–	0.36	–	0.13	–	0.35	–	0.40	–	0.41	–	0.18	–
J-stat (prob)	0.86	–	0.24	–	0.25	–	0.53	–	0.90	–	0.19	–	0.62	–	0.42	–

***** Figures in brackets correspond to t-stat. Estimation using generalised method of moments (GMM) and two lags in each case. **1** Annualised seasonally adjusted quarterly growth rates of HICP. **2** Annualised seasonally adjusted quarterly growth rates of HICP excluding energy and unprocessed food.

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We use a traditional expectations-augmented Phillips curve for an open economy as the theoretical background for our econometric estimates. Inflation is determined using three factors: inflation expectations (these may be forward or backward-looking), the cyclical component (output gap) and external factors (eg commodity prices):

$$\pi_t = \alpha\pi_t^e + \beta\pi_{t-1} + \lambda y_t + \gamma roh_t + \varepsilon_t.$$

π stands for the inflation rate, π^e for the expected inflation rate, y for the output gap and roh for commodity prices; t is the time index.[6]

The price dynamics to be explained are represented, on the one hand, by the harmonised index of consumer prices (HICP) and, on the other, by the core component (HICP excluding energy und unprocessed food). Annualised seasonally adjusted quarterly growth rates feed into the estimation equation. Inflation expectations are measured using Consensus Economics' six to ten-year inflation forecasts. Commodity prices are taken from the HWWI commodity price index (euro basis). Furthermore, we include the lagged inflation rate to address any possible persistence resulting from backward-looking expectations, among other factors.

In the past, irrespective of the procedure used to estimate the output gap, the same headline or core inflation rate has coincided with very different cyclical positions.[7] For instance, in 2000, when core rates were very low in all countries analysed, both the IMF output gap figures and the HP filter results showed an overutilisation of capacity, whereas in 2008-09 and 2013 the same core rates coincided with a – sometimes considerable – underutilisation of capacity. This already indicates that cyclical fluctuations have a relatively moderate impact on price developments. Furthermore, the figures show that medium-term expectations were very stable in the past, remaining around 2%. In the period under review, fluctuations in inflation rates seem to have

6 In many cases, the Phillips curve is estimated using the deviation of the observed unemployment rate from the long-term trend (NAIRU). However, under Okun's Law there is a relationship between the output gap and the gap derived using the unemployment rate.

7 As the seasonally adjusted quarterly growth rates are highly volatile, especially for the HICP, the chart and tables show year-on-year price changes. These show a slight cyclical lag which is not present in the annualised quarterly growth rates.

Cyclical sensitivity of inflation rates in the period from 1996 to 2013 depending on the output gap*

Item	Euro area				Germany				France				Italy			
	Headline rate1		Core rate2		Headline rate1		Core rate2		Headline rate1		Core rate2		Headline rate1		Core rate2	
	Output gap according to filter technique															
π^e	0.74	(5.0)	0.33	(3.5)	0.75	(12.1)	0.41	(3.9)	0.75	(4.3)	0.32	(4.7)	0.89	(4.4)	1.07	(21.1)
π_{t-1}	0.16	(1.3)	0.56	(4.7)	–	–	0.34	(2.5)	0.14	(1.0)	0.53	(5.3)	0.16	(1.1)	–	–
HP gap	0.33	(3.0)	0.13	(3.0)	0.40	(5.2)	0.15	(0.9)	0.39	(2.7)	0.16	(2.2)	0.41	(3.2)	0.20	(3.3)
Commodity prices	0.04	(2.0)	–	–	0.10	(3.7)	–	–	0.01	(0.5)	–	–	0.03	(1.5)	–	–
R^2	0.52	–	0.43	–	0.29	–	0.13	–	0.27	–	0.27	–	0.38	–	0.19	–
J-stat (prob)	0.28	–	0.07	–	0.08	–	0.30	–	0.40	–	0.08	–	0.11	–	0.14	–
	Output gap according to IMF forecast															
π^e	0.74	(4.6)	0.37	(4.0)	0.79	(13.0)	0.46	(4.1)	0.68	(3.6)	0.35	(4.2)	0.65	(4.7)	1.08	(21.6)
π_{t-1}	0.24	(1.8)	0.53	(5.0)	–	–	0.31	(2.2)	0.22	(1.4)	0.50	(5.6)	0.36	(4.7)	–	–
IMF gap	0.21	(3.1)	0.14	(4.5)	0.42	(7.6)	0.19	(3.4)	0.17	(2.4)	0.15	(3.9)	0.17	(4.2)	0.14	(3.2)
Commodity prices	0.02	(1.2)	–	–	0.09	(4.1)	–	–	0.02	(0.7)	–	–	0.03	(1.4)	–	–
R^2	0.36	–	0.45	–	0.35	–	0.10	–	0.25	–	0.31	–	0.27	–	0.22	–
J-stat (prob)	0.51	–	0.18	–	0.24	–	0.61	–	0.86	–	0.17	–	0.21	–	0.29	–

***** Figures in brackets correspond to t-stat. Estimation using generalised method of moments (GMM) and two lags in each case. **1** Annualised seasonally adjusted quarterly growth rates of HICP. **2** Annualised seasonally adjusted quarterly growth rates of HICP excluding energy and unprocessed food.

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had only a limited impact on inflation expectations.

First, regressions are performed for the period from 1996 to 2009, when the output gaps calculated using the two procedures are generally relatively similar. The impact of these output gaps proves to be statistically significant in all specifications. The estimated coefficients of cyclical sensitivity are practically the same irrespective of which output gap is chosen. Where there are deviations, for instance in the results for France, these are rarely statistically significant. The cyclical sensitivity of the HICP headline rates is higher than that of the core rates.[8]

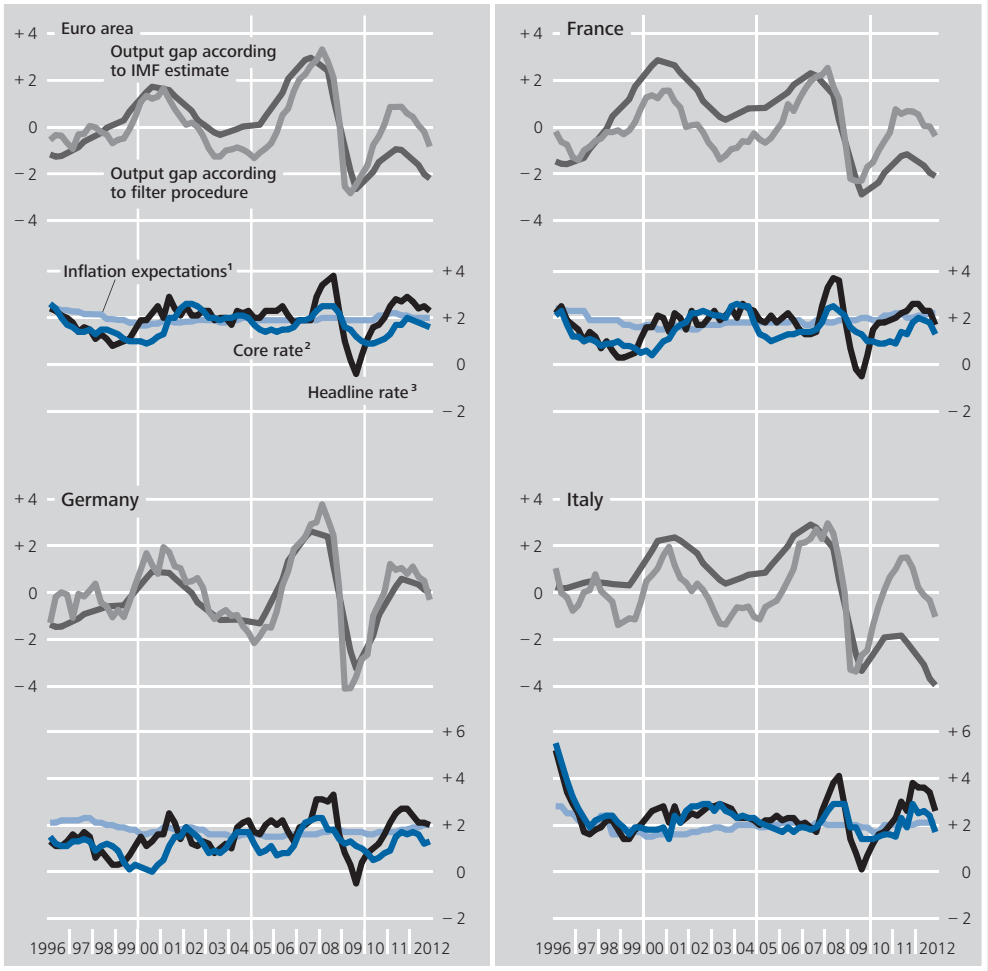
If the period is extended until 2013, ie to include the period where output gaps diverge more widely, the results then change significantly in some cases. The cyclical impact is still statistically significant in almost all cases, and the cyclical sensitivity of HICP headline rates still tends to be higher than that of the core rates. France and Italy are exceptions; in these countries the two inflation rates are shown to have almost identical levels of sensitivity to the IMF output gap estimates. Above all, however, there is often a significant divergence between the estimated coefficients for those specifications which differ only in the choice of output gap. Given the relatively similar estimates of the cyclical position for Germany, divergences are the lowest for this country. By contrast, the differences are greater for the HICP headline rate for the euro area, France and Italy. In all cases cited above, cyclical sensitivity calculated using the IMF figures is distinctly lower than that calculated using the HP filter-based output gaps. The difference between the estimated coefficients is statistically significant for Italy in particular. These observations are true, but to a lesser extent, for the core rates, too.

A comparison of the estimated cyclical sensitivity between the two time periods reveals no notable differences for Germany due to the similar output gap developments. By contrast, for the euro area, France and Italy, the HP filter-based estimates of the output gap coefficients tend to be higher for the entire period from 1996 to 2013 than in the period up to 2009,

8 See also A Fröhling, K Lommatzsch, Output sensitivity of inflation in the euro area: Indirect evidence from disaggregated consumer prices, Deutsche Bundesbank Discussion Paper, No 25/2011.

Output gaps and inflation rates

%, quarterly



Sources: ECB, IMF, Consensus Economics and Bundesbank calculations. **1** Pursuant to the six to ten-year Consensus Forecast. **2** HICP inflation excluding energy and unprocessed food; year-on-year change. **3** HICP inflation; year-on-year change.

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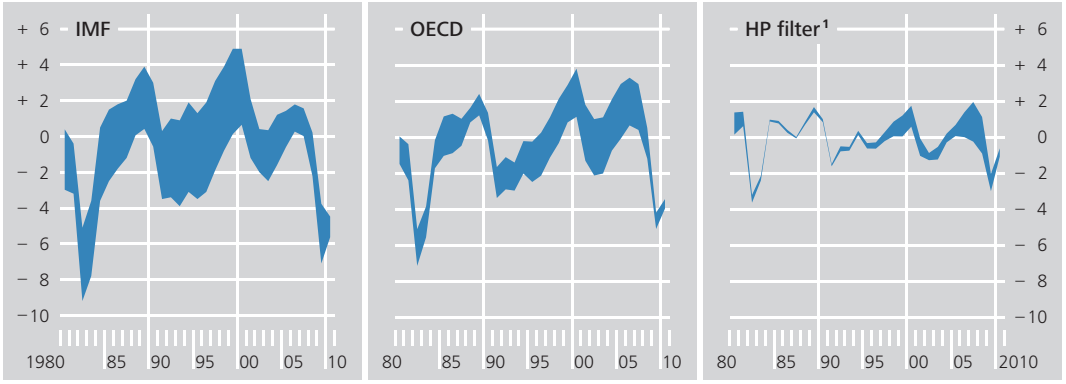
while sensitivity calculated using IMF estimates declined. The shifts in the HICP headline rates are higher than those in the core rates. However, the differences between the estimated coefficients are not statistically significant in any of the cases.

Overall, it can be said that the differences between the output gaps estimated using different procedures are reflected in the estimated cyclical sensitivity of the inflation rate even though the Phillips curve relationship is confirmed for all specifications. A wider output gap tends to be "compensated" by a lower response coefficient. The cyclical impact is thus relatively small, irrespective of the procedure used to calculate the output gap. However, it is not possible to confirm the hypothesis that the relationship weakened even further during the crisis purely on the basis of the estimates shown here. A trend towards a weaker relationship is only observed when using the comparatively wide negative output gap estimates by the IMF and when there is a major divergence between these figures and those calculated using the HP filter.

Range* of estimates of the output gap in the United States since spring 1999 WEO/EO**

As a percentage of potential output



Sources: IMF (World Economic Outlook (WEO) April 1999 to October 2013), OECD (Economic Outlook (EO) Nos 65 to 94) and Bundesbank calculations. * Minimum and maximum. ** Only estimates of the output gap for past years are considered. 1 Hodrick-Prescott filter with smoothing parameter of 6.25 applied to real-time data on real GDP (according to WEO), which were extrapolated based on the average growth rates of the last ten years.

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is examined below.[13] Every publication contains a time series with estimates of an economy's capacity utilisation in recent years. Only data on historical gaps are included in order to exclude revisions that are obviously the result of uncertainties in connection with macroeconomic forecasts. That means that, looking for instance at the WEO of April 1999, the last estimate included in the analysis refers to the output gap in 1998. Conversely, the WEO data of the spring of the following year represent the first historical estimate of overall capacity utilisation in 1998. Particular attention is paid to these initial estimates available from 1998 onwards, as they are the best proxy for the current end, which is important for economic policymakers. To determine reliability, they are compared to the most recent estimates taken from the respective autumn 2013 publications.[14] The evolution of the estimates from the initial to the most recent is likely to be interesting, as is the question as to whether, and to what extent, information on output gaps has been revised in the more distant past, which is why the period prior to 1998 is also considered.[15] At the same time, the reliability of the estimates that have been derived by simple smoothing of real-time data on the real GDP using the HP filter is analysed as the benchmark.[16]

End-point issue for estimates based on HP filter

The analysis of the output gaps obtained using the HP filter confirms and illustrates the results of Orphanides and van Norden (2002). If one looks at the difference between the maximum and the minimum figures for the output gap in each individual year, a mean range of 1 percentage point is, for instance, calculated for the United States in the 1998 to 2010 period, for which initial estimates can be observed at the current end. Looking at the most recent estimates and neglecting the sign, the average output gap for this period also works out to around 1%. Consequently, the revisions are, in fact, quite large in relation to the actual gaps.

13 The relevant IMF data are freely available, while access to the OECD data through OECD iLibrary is limited to subscribers. OECD data are, in principle, even available as far back as the EO No 60 of autumn 1996.

14 The WEO data of April 2014 have been disregarded as there are, to date, no comparable OECD estimates.

15 Estimates of the output gap dating back to the year 1980 are considered here, although data even went back to 1970 prior to the autumn 2003 WEO. On the other hand, the observation period is concluded with the output gap for 2010, for which at least six historical estimates are available.

16 For more on the concrete details of the derivation, see footnote 8. The choice of the smoothing parameter of 6.25 follows Koske and Pain (2008), who examine the susceptibility for revision specifically of the OECD data compared to real-time estimates based on the HP filter. The results of the analysis presented below do not change materially in qualitative terms if a parameter of 100 is assumed instead, which is also used frequently. See I Koske and N Pain (2008), The Usefulness of Output Gaps for Policy Analysis, OECD Economics Department, Working Paper No 621.

Dispersion of estimates* of output gap in selected periods across publications

Country	Period	Mean range[1]			Change of sign[2]			*Memo item* Mean absolute output gap[3]		
		IMF	OECD[4]	HP filter[5]	IMF	OECD[4]	HP filter[5]	IMF	OECD[4]	HP filter[5]
United States	1998-2010	2.9	2.4	1.0	7	7	3	2.0	2.1	1.1
	1980-1997	4.0	1.8	0.3	13	7	2	2.0	1.7	1.0
Japan	1998-2010	1.9	2.5	1.2	0	4	6	1.6	2.1	1.0
	1980-1997	2.4	2.3	0.7	4	8	2	2.4	2.5	0.9
Germany	1998-2010	1.9	1.9	1.1	5	4	4	1.4	1.6	1.4
	1980-1997	3.6	3.1	0.3	7	8	1	2.5	1.4	0.8
France	1998-2010	2.6	2.7	0.9	11	8	5	1.6	1.6	0.9
	1980-1997	1.6	2.2	0.5	5	5	3	1.2	1.4	0.7
United Kingdom	1998-2010	2.3	2.2	1.0	9	7	8	1.9	1.7	1.1
	1980-1997	2.6	2.5	0.5	7	3	2	1.4	1.8	1.1
Italy	1998-2010	3.1	3.3	1.0	10	11	6	1.6	1.9	1.1
	1980-1997	4.2	2.0	0.4	10	5	2	1.6	1.3	0.6
Canada	1998-2010	2.1	2.0	1.0	8	5	7	1.6	1.5	0.9
	1980-1997	10.9	1.9	0.3	16	4	1	1.9	2.0	1.3

* Based on estimates from WEO April 1999 and EO No 65 up to WEO October 2013 and EO No 94 respectively. Only estimates of the output gap for past years are considered. **1** Arithmetic mean of the range of estimated output gaps calculated for individual years; in percentage points. **2** Number of years for which the estimated output gap changes sign at least once across publications. **3** According to autumn 2013 estimates; as a percentage of potential output. **4** OECD data from more recent EOs start 1985-86, for Germany from 1991. **5** Application of HP filter with smoothing parameter of 6.25 to real-time data on real GDP according to the WEO databases (logarithmic and extrapolated using average growth rates).

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Deviations are particularly pronounced for the cyclical highs. For instance, the range reached 1¼ percentage points in 1999-2000, and even figures of 2 percentage points and more in 2007-08. This demonstrates the unreliability of trend extraction by the HP filter at the current end, when economic momentum turns. By contrast, the output gaps estimated for the period prior to 1998 do not deviate much. This is primarily because further economic developments are known for this period, and trend output only needs revising to take account of small corrections to historical GDP data.[17]

Large-scale revisions to IMF and OECD data, particularly for output gaps dating back many years

However, the IMF and OECD estimates yield a different picture. The range of their data appears to be significantly wider. However, the fact that the international organisations estimate considerably larger output gaps on average puts this into some perspective. In other words, they assume a higher cyclical amplitude but a smoother potential growth path than the HP filter with the specifications chosen here.[18]

In addition, it is striking that it is not only the output gaps at the current end that are subject to large-scale revisions, but also those for more distant years. In fact, the IMF even appears to correct its data for the period prior to 1998 more than its estimates for more recent output gaps. For instance, the autumn 2000 WEO reported capacity underutilisation of 5½% of potential output for the US economy in 1982. In September 2002, the Fund revised its estimate to -9¼%, before lowering it to -5% again in its 2007 spring publication. The estimates of the output gap in the years 1983 to 1985 also fluc-

17 However, a similar problem occurs at the historical end as some time series go back to 1970, while others do not start until 1980.

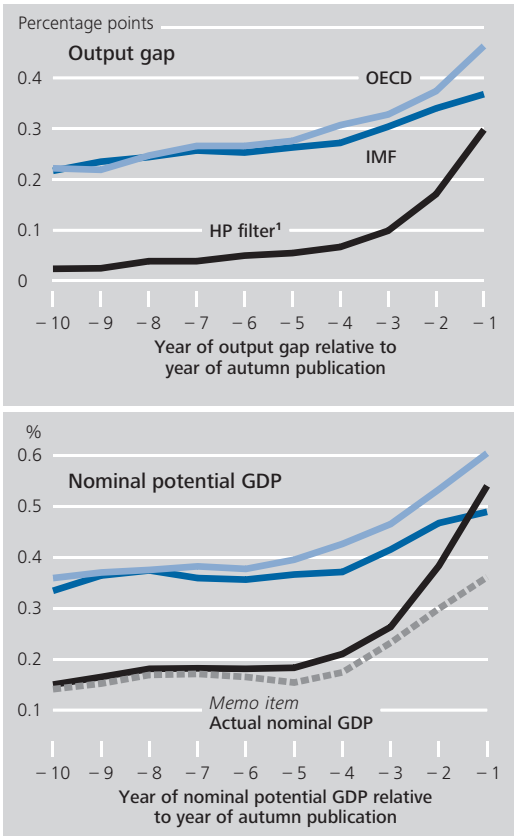
18 One way to obtain a relative measure of the size of revisions would be to look at the mean range of the estimates in relation to the mean absolute output gap. If the smoothing parameter of the HP filter is set to 100, the resulting cyclical fluctuations are of similar magnitude to those in the data supplied by the international organisations. The range of the (revised) estimates based on the HP filter is also larger as a result; however, the relation between the mean range and the mean absolute output gap tends to remain unchanged.

tuated by up to 4 percentage points. And revisions like those observed for the United States are by no means unique. The estimates for Canada definitely represent an outlier. In the October 2007 WEO, IMF staff raised the country's output gap for 1980 from just under 2% to almost 10%, and the figures for the following years were revised by a similar amount. However, these revisions were retracted only two publications later. Across all publications studied here, the IMF estimates for the Canadian output gap in the years 1980 to 1997 reach an average range of around 11 percentage points. For Italy, too, IMF staff corrected its estimates of the cyclical position in the 1980s, massively in some cases. The April 2009 WEO upped the output gap for 1980 from 3% to 13¼%. The autumn 2013 edition still reported overutilisation of 12¼% for 1980, which fell to just over 1% the following year. Given that real GDP expanded by less than 1%, this implies a sudden increase in Italy's potential output by around 12% in 1981.

Signs of estimates often change across vintages

As the revisions are so large, it is not uncommon for a negative output gap to become positive, and *vice versa,* across the different vintages of estimates. For the international organisations, the same applies to estimates of the cyclical position in the more distant past. Looking at the estimates produced by the OECD since 1999 for the output gap in the US economy between 1980 and 1997, seven of those years saw at least one sign change, which is exactly the same number as in the later period. The IMF changed the sign of its estimates for as many as 13 of the 18 years in the earlier period; only the output gaps between 1981 and 1983 and in the 1988-89 period were consistently confirmed as being below and above zero, respectively. By contrast, there were generally only a few sign changes in the earlier period for the cyclical positions obtained using a simple filter procedure.[19] Based on this criterion, the simple smoothing procedure at least does not tend to perform any worse for the 1998-2010 period than the international organisations' estimates.[20] Japan is an exception, however. The IMF in particular has not revised its hypothesis of lasting capacity underutilisation in Japan's economy, which is probably founded on the country's mild but persistent deflation.

Size of the revisions* to estimates for the G7 countries depending on the length of the intervening period



Sources: IMF (World Economic Outlook (WEO) from April 1999 to October 2013), OECD (Economic Outlook (EO) Nos 65 to 94) and Bundesbank calculations. * Mean absolute revision to estimates for the stated year vis-à-vis the previous publication. Simple arithmetic mean across publications and countries. **1** Hodrick-Prescott filter with a smoothing parameter of 6.25, applied to real-time real GDP data (from WEO) which were extrapolated from the average growth rates over the past ten years.

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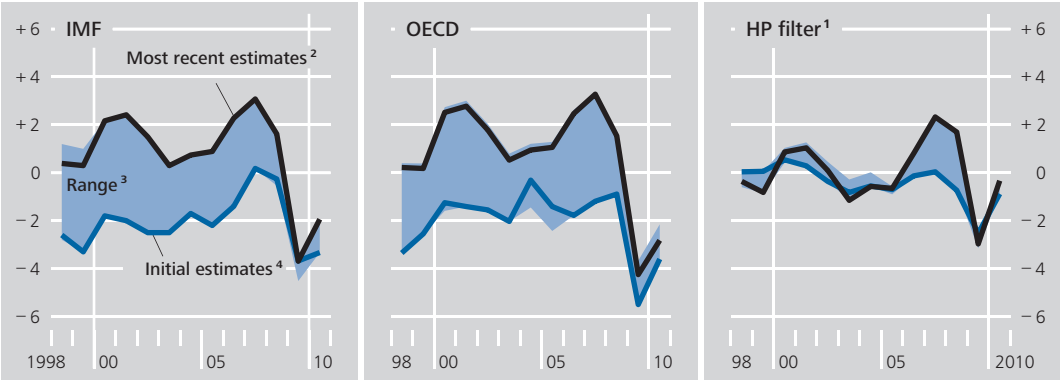
19 The same applies when the HP filter is given a smoothing parameter of 100.

20 This is striking because only average past growth rates – and thus no information on actual developments in the relevant year or subsequently – were used to extrapolate the underlying GDP time series at the current end, which ought to put the simple smoothing procedure at an informational disadvantage to the estimates produced by the international organisations.

Evolution of output gap estimates for Italy

% of potential output



Sources: IMF (World Economic Outlook (WEO) from April 1999 to October 2013), OECD (Economic Outlook (EO) Nos 65 to 94) and Bundesbank calculations. **1** Hodrick-Prescott filter with a smoothing parameter of 6.25, applied to real-time real GDP data (from WEO) which were extrapolated from the average growth rates over the past ten years. **2** Data current in autumn 2013. **3** Minimum and maximum of all estimates. **4** Estimates from spring WEO/EO of the year following the stated year.

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Long historical reach of the international organisations' revisions …

The fact that the international organisations' usual corrections have a much longer historical reach than those performed using a simple filter procedure is probably the main reason why their revisions are comparatively large and also stretch back into the distant past. This becomes apparent when observing the adjustments to the time series for the output gap from one WEO to the next and calculating their mean across the different publications and countries.[21] Revisions to estimates produced using the HP filter are generally clustered around the current end of the time series; additional observations cause revisions to the cyclical position only for the immediately preceding years. The influence of additional observations wanes as the length of the intervening period increases, depending on the choice of smoothing parameter and thus on the assumed length of a business cycle.[22] Output gaps in the distant past are therefore only corrected via rather infrequent and usually small revisions to historical GDP data. The picture for the international organisations' estimates is different, however. Revisions to the output gap for years in the more distant past are only somewhat smaller than adjustments at the current end and generally still have a discernible impact.

The question remains as to what causes the international organisations' revisions to estimates in the distant past. One hypothesis would be that the statistical agencies shift the time path of real GDP upwards or downwards. The trend output extracted using a statistical smoothing procedure would then follow this level adjustment quasi-automatically, meaning that the gap based on the HP filter would remain unaffected. However, if the IMF and OECD did not revise their assessment of the potential output path, they would have to correct their capacity utilisation time series accordingly.[23] Yet this scenario seems unlikely, if only because – all other things being equal – a parallel shift of potential output would appear logical if the level of real GDP is corrected. In addition, revisions to historical GDP data tend to be small. Alternatively, the adjustments to the output gaps could be caused by the international organisations' reassessments regarding the paths of potential output. To decide which of these competing hypotheses is cor-

… due to reassessments regarding path of potential output

21 Here, we prefer a simple arithmetic mean across countries to a weighted average, as we are interested in the typical revision rather than the aggregate one. In an aggregate analysis based, for example, on nominal GDP weights, the US output gap would always have a dominant influence.

22 When a smoothing parameter of 100 is assumed, the revisions to the estimates based on the HP filter are initially somewhat larger than in the specification preferred in this analysis. In addition, they remain considerable for somewhat longer as the intervening period increases.

23 Koske and Pain use a similar line of argument (2008).

rect, the contributions of the corrections of actual and potential GDP to the output gap revision need to be identified. Yet a breakdown of this kind is not possible for the real variables, as, for conceptual reasons, their levels are not always comparable and the necessary differences therefore cannot be calculated.[24] However, whether the gap expressed as a percentage of potential output is related to real or nominal variables has no impact on the gap's size. Revisions to nominal variables can easily be calculated in currency units and compared.[25] Such an analysis of nominal variables confirms the hypothesis that new estimates of the potential output level by the international organisations essentially cause the revisions to output gaps, particularly in the distant past.

International organisations' initial output gap estimates tend to be too pessimistic

The susceptibility of initial estimates to revision provides some insight into the reliability of estimates at the current end. Looking at the data of the international organisations, it becomes clear that the subsequent corrections to these initial estimates are not only large but also tend to be in the same direction. Thus, both the IMF and the OECD generally underestimated the output gap for the 1998-2010 period and revised their estimates upwards in later rounds. The estimates based on the HP filter do not show a bias of this size.[26] For example, the IMF's estimates initially showed an underutilisation of capacity in the Italian economy for every single year between 1998 and 2006. By contrast, the output gaps for this period all had a positive sign in the October 2013 WEO, and some of the upward revisions were very large. For the 2000-02 period, the IMF ultimately published cyclical positions of +1½% to 2½% of potential output, compared with its initial estimates of -1¾% to -2½%. For Italy, the OECD even changed all of the negative output gaps estimated for the 1998-2008 period into positive ones. Another point to note is that even a very high initial estimate for underutilisation does not necessarily preclude a sharp subsequent revision. In the spring 1999 WEO, the IMF estimated Japan's 1998 output gap at -5¾%, before revising it to only -1½% in its autumn 2013 publication.

Initial HP filter-based estimates less biased

The tendency towards upward corrections becomes apparent when calculating the mean of the revisions to initial estimates across the 1998-2010 period. As these upward revisions are not offset by downward corrections of a similar size, there are fairly high mean upward revisions to the international organisations' estimates for most of the G7 economies. Indeed, they often come close to the mean absolute revision which disregards the sign. The IMF's estimates for the United States and the OECD's estimates for Japan are the only exceptions to this rule. By contrast, the mean revision to the initial estimates based on the HP filter is not generally as high in relation to the correspond-

24 Instead, Koske and Pain (2008) decompose the revision to the change in the output gap into the revision to the growth rates for real actual GDP and the revision to the growth rates for real potential GDP. They conclude that the revisions to the change in the output gap are due to a greater extent to corrections to actual GDP growth. However, it is important to emphasise that this issue is separate from the matter of explaining the revisions to the output gap level. For example, if there is simply a parallel upward or downward shift of the estimated time path for the potential output path, this does generally alter the level of the output gap, but output gap changes from one period to the next remain entirely unaffected. See I Koske and N Pain (2008), op cit.

25 For the euro-area countries under review (Germany, France and Italy), the data for the period before the launch of the euro can be provided on a uniform basis using the fixed conversion rates. Generally, nominal potential GDP is derived from nominal actual GDP and the output gap.

26 If a smoothing parameter of 100 is used, the bias is somewhat larger than in the HP filter specification preferred in our analysis, but it still tends to be smaller than that affecting the international organisations' estimates. Koske and Pain (2008) already observed that revisions to the OECD's initial estimates were not random but generally had a substantial bias, while revisions using the HP filter were not biased to the same degree. However, it is important to note that they define the revision merely as the difference between the estimates in the first and fourth year after the reference period for the output gap. The estimates in the fourth year after the reference period are by no means "final" OECD estimates, which means that subsequent corrections are omitted from the analysis. In addition, Kempkes (2014) finds that international institutions' (IMF, OECD and European Commission) estimates of output gaps for EU countries for the current year and the following year have frequently been too negative. However, the study finds that estimates derived from the HP filter often have a similar bias, which is probably due in part to the influence of the underlying real GDP projections. See I Koske and N Pain (2008) op cit, and G Kempkes (2014), Cyclical Adjustment in Fiscal Rules: Some Evidence on Real-Time Bias for EU-15 countries, Finanzarchiv, forthcoming.

Revisions* to the initial estimates for the output gap between 1998 and 2010

Percentage points

Country	Mean revision[1]		
	IMF	OECD	HP filter[2]
United States	0.3 (1.2)	1.4 (1.6)	0.3 (0.8)
Japan	1.3 (1.3)	0.6 (1.1)	0.2 (0.8)
Germany	1.3 (1.3)	0.8 (0.9)	0.1 (1.0)
France	2.4 (2.4)	2.1 (2.1)	0.3 (0.6)
United Kingdom	2.1 (2.2)	1.3 (1.6)	0.5 (0.7)
Italy	2.9 (2.9)	2.9 (2.9)	0.4 (0.8)
Canada	1.8 (1.8)	1.5 (1.6)	0.4 (0.7)

* Difference between the estimates in the October 2013 WEO/EO No 94 and the estimates in the spring publications of the IMF/OECD in the years from 1999 to 2011 for the output gap in the preceding year. **1** Figures in brackets show the mean absolute revision. **2** HP filter applied with a smoothing parameter of 6.25 to real-time real GDP data (logarithmised and extrapolated from average growth rates) from the WEO databases.

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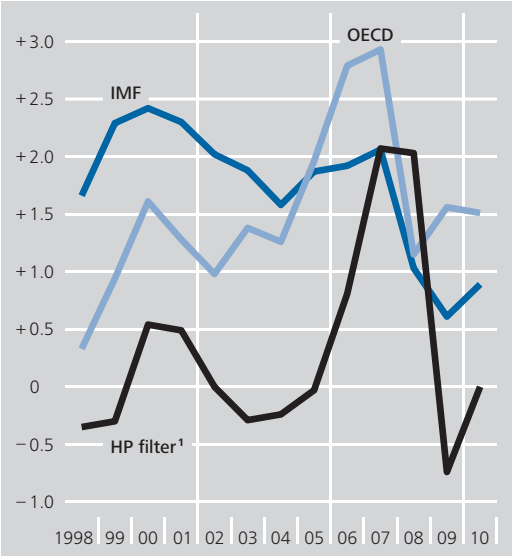
Mean revision across the G7 countries to initial output gap estimates*

Percentage points



Sources: IMF (World Economic Outlook (WEO) from April 1999 to October 2013), OECD (Economic Outlook (EO) Nos 65 to 94) and Bundesbank calculations. * Difference between autumn 2013 estimates and initial outturn estimates. The mean revision across the G7 countries is a simple arithmetic mean taking account of the sign (positive or negative). **1** Hodrick-Prescott filter with a smoothing parameter of 6.25, applied to real-time real GDP data (from WEO) which were extrapolated from the average growth rates over the past ten years.

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ing figure calculated when the signs are disregarded. This is mainly because the HP filter procedure, with its endpoint bias, also generates downward revisions. Yet the upward corrections are greater in number, particularly in 2007 and 2008. The upward corrections to the international organisations' estimates are not clustered in a similar fashion around a cyclical peak. Instead, the bias affecting their initial estimates appears to be more of a general problem.

Hesitancy to recognise changes in trend growth

One possible explanation could be the trend towards slower GDP growth in the major industrial countries during the period under review. If the IMF and the OECD had been hesitant to recognise this change, they might initially have wrongly interpreted the deceleration of macroeconomic growth as a cyclical problem.[27] This would be consistent with the fact that, in the OECD publications prior to 1999 for which databases are available, the initial estimates of the US output gap were too high. At that time, potential growth in the United States had accelerated unexpectedly. In the United Kingdom too, trend growth had strengthened around the mid-1990s, but the OECD did not subsequently perform consistent downward revisions on its initial estimates of the UK output gap. The international organisations' corrections to their estimates of the earlier level of potential output may be even more important than their revisions to trend growth in the past few years. As shown previously, level adjustments of this kind can lead to far-reaching revisions of past output gap estimates.

Drawn-out process of assessing persistence of output losses …

How the international organisations change their appraisals of the path of potential output in response to recessions is likely to be an important factor in this context. If an observed economic slump is initially deemed to be a

27 This is also surmised by Kempkes (2014). By contrast, Koske and Pain (2008) point to the impact of revisions to actual GDP on HP filter-based estimates of trend output. As explained above, however, this does not tally with the international organisations' extensive corrections to nominal potential output. See I Koske and N Pain (2008), op cit, and G Kempkes (2014), op cit.

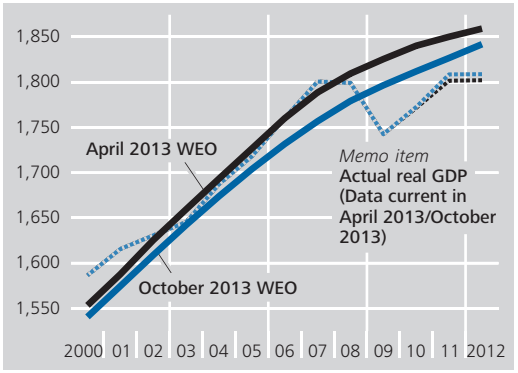
purely temporary phenomenon, this implies a large underutilisation of capacity. Yet if the economy does not recover swiftly, thus making a return to the earlier growth trend an increasingly distant prospect, the path of potential output might be lowered at the current end. The organisations may then come to realise that macroeconomic developments prior to the recession were not sustainable, and might also revise the level of potential output in previous years downwards while raising the output gap throughout.

… by the OECD …

These kinds of considerations appear to have informed the actions of the OECD in particular in connection with the 2008-09 global recession. In its March 2009 Interim Report, the OECD left the 2007 output gap for its entire economic area unchanged on its December 2008 estimate (+1%), while forecasting a very high level of underutilisation for 2009 (-6½%) and 2010 (-8½%). When the world economy appeared to be on the road to recovery in spring 2009, the OECD debated whether it should stick to its previous hypothesis of a "bust without boom".[28] By contrast, mechanistic application of the OECD's usual method, in which statistical filters are applied to at least some of the time series which feed into the production function approach and are extrapolated, would, in retrospect, have shown a marked boom prior to the crisis. For quarterly data, the output gap would then have peaked below +4%, before falling to just short of -4%. At that time, the OECD opted for the middle road of raising its estimate for the 2007 output gap moderately to +1¾% while projecting underutilisation amounting to 5¼% of potential output for 2009. Subsequently, however, the OECD continued to intensively investigate the impact of the crisis on the trend path of aggregate output in the advanced economies.[29] In its autumn 2013 EO, it put the OECD output gap at +3¼% in 2007 and -3¾% in 2009, which is probably fairly close to the figures in its earlier alternative scenario.

IMF estimates of potential output* in France

€ billion, at previous year's prices, reference year 2005



Sources: IMF World Economic Outlook (WEO) for April and October 2013 and Bundesbank calculations. * Bundesbank calculations based on IMF data on real GDP and the output gap.

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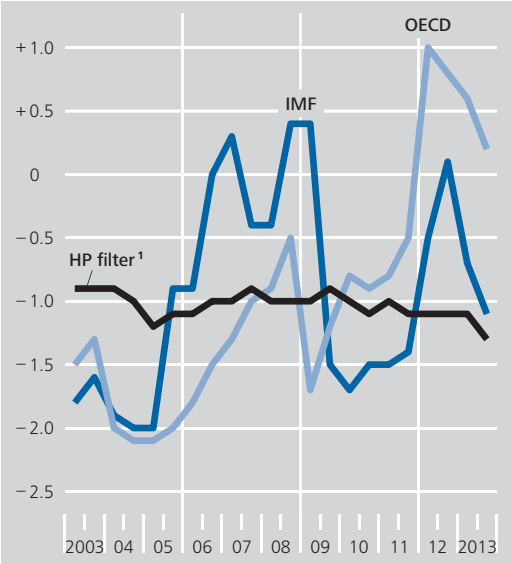
… and the IMF

The IMF recently markedly revised its output gap figures for France spanning an extended period of time, possibly for similar reasons.[30] Compared with its spring publication, the IMF's autumn 2013 WEO raised the estimates for the utilisation of aggregate capacity by 1¼ percentage points on average over the 2000-12 period. However, the data on actual real GDP were corrected only slightly, and solely for very recent years. The upward revision to the output gap is therefore mostly due to a corresponding reduction in the estimated potential output. For 2007, the peak of that business cycle, the IMF now reports a substantial overutilisation amounting to 2½% of potential output, having previously estimated only a small positive output gap (+¾%).

28 See OECD (2009), The Sensitivity of Output Gap Estimates to the End-Point Treatment, Economic Outlook, No 85, p 246.
29 See OECD (2010), The Effect of the Crisis on Potential Output, Economic Outlook, No 87, pp 238-239, and OECD (2013), The Effect of the Crisis on Potential Output, Economic Outlook, No 93, p 201.
30 See K Cheng (2011), France's Potential Output during the Crisis and Recovery, IWF, France, Selected Issues Paper, Country Report, No 11/212, and J Benes and E Pérez Ruiz (2013), Potential GDP Estimates for France: Prudent (and Calling for Action), IWF, France, Selected Issues Paper, Country Report, No 13/252, pp 15-28.

Evolution of the estimates for the output gap in the United States in 2002 across publications*

% of potential output



Sources: IMF (World Economic Outlook (WEO) from April 2003 to October 2013), OECD (Economic Outlook (EO) Nos 73 to 94) and Bundesbank calculations. * Publication in spring and autumn of the stated year. **1** Hodrick-Prescott filter with a smoothing parameter of 6.25, applied to real-time real GDP data (from WEO) which were extrapolated from the average growth rates over the past ten years.

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Implications and conclusion

International organisations' estimates also prone to revision

The international organisations' tendency to occasionally re-estimate paths of potential output spanning long periods of time means that the resulting output gaps may be revised even decades on. It is therefore questionable whether the IMF and OECD figures possess the qualities of "final" estimates, upon which empirical analyses often rely. For example, the two institutions' estimates of the US output gap in 2002, which is likely to have played an important role in the 2003 deflation debate,[31] do not appear to converge towards a given figure. In addition, the size and bias of the revisions to initial estimates of potential output and the output gap show that, particularly at the current end, the IMF and OECD figures are subject to great uncertainty.

It is therefore important to be cautious about using the estimates to assess economic policy, for example.[32] Looking at monetary policy, the average range of just under 3 percentage points for the IMF estimates of the US output gap between 1998 and 2010 would, for example, imply a band of 1½ percentage points for the appropriate policy rate when applying the Taylor rule with its original 50-50 weighting of the target deviations for inflation and output.[33]

Uncertainty about Taylor rate

Biased cyclical adjustment in context of fiscal rules

The bias in the international organisations' real-time estimates could have had tangible repercussions if their data had been used in the context of fiscal rules. Simulations for selected EU countries show that this would have led to significant unintended increases in general government debt ratios (see box on pages 33 and 34). One option for dealing with a bias of this kind in the cyclical adjustment procedure for general government deficits would be to set up a "business cycle compensation account". If, after an extended period, this account showed that the cyclical components did not offset each other on average over time, the permitted scope for borrowing could be widened or narrowed accordingly.

Uncertainty about persistence of output losses in the most recent crises …

The deceleration in major industrial countries' trend growth in recent decades is evident and, not least given their increasing demographic change, also plausible. Estimates of the level of potential output are a prerequisite for assessing capacity utilisation. One possible conclusion which can be drawn in relation to the global

31 See IMF, Could Deflation Become a Global Problem?, World Economic Outlook, April 2003, pp 11-13.
32 Orphanides (2002) argues that the US Federal Reserve's policy decisions in the 1970s were consistent with the application of a "modern" systematic, forward-looking policy approach, but that incorrect real-time estimates of potential output ultimately led to policy errors. See A Orphanides (2002), Monetary-Policy Rules and the Great Inflation, American Economic Review, Vol 92, pp 115-120, and Deutsche Bundesbank, Monetary policy under uncertainty, Monthly Report, June 2004, pp 15-27.
33 The Taylor rate also depends on the equilibrium real interest rate, which was set at 2% (constant) in the original version. In later applications this equilibrium real interest rate is often approximated by potential growth. The range for this estimate would then likewise affect the range of the Taylor rate. See J B Taylor (1993), Discretion Versus Policy Rules in Practice, Carnegie-Rochester Conference Series on Public Policy, Vol 39, pp 195-214.

The impact of biased potential output estimates within fiscal rules

Estimates of the output gap also play an important role in the analysis of public finances and in the context of budgetary rules. They can be used to assess the impact of the economic cycle on public finances. Adjustment for cyclical factors (known as cyclical adjustment) is a key stage in determining the "structural" position of the government budget. Both the German debt brake and the Stability and Growth Pact are based on cyclically-adjusted variables. This is intended to keep public debt at sustainable levels, whilst also allowing the automatic stabilising effect of cyclically induced changes in the fiscal balance. Specifically, budgetary rules designed to limit the build-up of debt are based on the idea that the cyclical components identified are largely symmetrical in the longer term. This will, it is hoped, ensure that negative cyclical components in recessions and positive cyclical components in booms largely balance each other out, and thus debt caused by cyclical components does not accumulate systematically over time.

Because the cyclical factors cannot be observed directly and are not clearly quantifiable using a generally accepted method, they must be estimated on the basis of the information available using a procedure deemed to be appropriate (see also main article beginning on page 13). In the cyclical adjustment method which is currently used for the European Stability and Growth Pact and the German government's national debt rule, the cyclical component is the product of the macroeconomic output gap and the average responsiveness of the government budget to this gap (budget sensitivity). Budget sensitivity therefore measures the impact of cyclical fluctuations in gross domestic product (GDP) on the fiscal balance. It is assumed to be constant over time and is only revised intermittently. In order to fulfil the symmetry criteria described above, negative and positive output gaps which are used to calculate the cyclical components must therefore neutralise each other over time.

Output gap estimates are subject to considerable uncertainty, especially at the current end, and are often revised significantly at a later date. This is unavoidable since expected future developments play a crucial role in calculating an economy's cyclical situation at the current end. If these expectations prove to be incorrect, the assessment for the earlier years also changes retrospectively. In terms of the objectives of budgetary rules, this can pose a problem if the procedure for estimating potential output is basically symmetrical but the macroeconomic outlook is regularly assessed too favourably at the time the estimation is made. Calculations would thus largely show cyclical underutilisation, which would justify the resulting cyclical deficits. Because these deficits would not be offset by corresponding cyclical surpluses (and subsequent revisions are not usually taken into account under the rules), this bias would involve an undesirable accumulation of debt.

Over the last 15 years, the output gaps for many countries in fact show a negative bias as estimated in real time by international organisations.[1] In other words, the cyclical

1 Specifically, "real time" refers to the estimate that would have been relevant to the fiscal plan in the context of the aforementioned budget rules. For example, the estimate from the autumn of the year preceding the budget year is generally used when the Bundestag approves the Federal budget. During the approval of the budget plan for 2013, compliance with the debt brake was assessed using estimates of potential output from autumn 2012.

position in many countries was systematically estimated too pessimistically in real time (ie potential output was overestimated).[2] If these real-time estimates had been used in the context of a fiscal rule such as the debt brake for the German central government, the actual scope for borrowing would have been systematically higher than the rule intended.

The quantitative significance of this real-time bias for debt ratios can be illustrated using simulations.[3] The data set used here includes output gaps estimated by the OECD, the IMF and the European Commission. Between 12 and 15 EU member states are observed over a period of 10 to 17 years. In each case, real-time data from the autumn of the previous year are compared with the spring 2013 estimations of the institution in question.

For the OECD data, the simulations show that, in itself, debt in the amount of the real-time cyclical fiscal balances would have caused a relatively high increase in the debt ratio in the magnitude of 15 percentage points (unweighted cross-country average over a period of 17 years, from 1996 to 2012). For most of the countries, these effects are statistically significantly different from zero. The simulations carried out using IMF data produce a similar result. They produce an increase in the debt ratio in the magnitude of 10 percentage points within 12 years (2001 to 2012), and the effects are also largely significant. EU data are only available for a shorter period (2003 to 2012), and the simulations for these show quantitatively weaker results. The effects are also less significant. However, the results of these simulations also indicate that the bias of the cyclical components leads to an average debt ratio increase of 6 percentage points.

If the real-time output gap as estimated by the OECD, IMF and the European Commission had been used for cyclical adjustment under fiscal rules, this would have resulted in considerably higher debt ratios than the rules intended.[4]

All in all, the simulations illustrate the risk that fiscal rules referring to cyclically adjusted fiscal balances may fail to curb debt as desired because potential output is regularly overestimated. To ensure that levels of new borrowing are not systemically too high compared to the target set by the budget rules, potential biases in the real-time cyclical components should therefore be taken into account separately. This could be done by keeping a record of each cyclical component used to assess compliance with the rules. The debt brake in the German Land Hesse, for example, provides for a control account for the real-time cyclical components *(Konjunkturausgleichskonto)*. If after an extended period, say a full economic cycle (eg eight to ten years), the cyclical components do not turn out to be roughly balanced on average, the borrowing limit for the subsequent period could be raised or lowered accordingly. Such a correction mechanism would be relatively easy to implement and would automatically become less important if estimates became more precise or estimation errors were symmetrical.

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2 See also Deutsche Bundesbank, Some evidence on biased cyclical adjustment within fiscal rules, Monthly Report, August 2012, pp 68-70.
3 See G Kempkes (2014), Cyclical adjustment in fiscal rules: some evidence on real-time bias for EU-15 countries, Finanzarchiv, forthcoming.
4 In the case of the EU production function, the effect of the bias on the debt ratio is not statistically significantly different from zero for Germany. Furthermore, revisions of the cyclical factors after the budget outturn also have an impact on the central government's borrowing possibilities in the context of the national debt rule. This general discussion therefore does not allow direct conclusions to be drawn about the effect of the bias in this context.

downturn seen in 2008 and 2009 is that the paths of potential output estimated before economic activity plummeted were overly optimistic for a large number of advanced economies. Consequently, earlier growth paths are probably no longer achievable, particularly for some European countries. Substantial macroeconomic imbalances built up in these countries in the years prior to the global economic downturn and unwound during the crisis, and painful adjustment processes are now underway.[34] Attempts to explain this merely through a major shortfall in aggregate demand are far from convincing. If these explanations are based on the international institutions' output gap figures, it is important to remember that these estimates are subject to great uncertainty and the staff of these organisations revise their perception of the capacity available to an economy only gradually.

… means that output gap estimates should be treated with particular caution

There is a general awareness of the difficulty of reliably estimating potential output and the output gap, particularly in the past few years. This is illustrated, not least, by the ongoing debate among national and international institutions about the impact of the crisis on long-term economic developments and about the causes of incorrect estimates in the past.[35] Economic policy should take account of the uncertainty about the current cyclical position – for instance, by drawing on the results of various procedures for calculating the output gap or by using alternative indicators. In the process of estimating price and cost pressures, measures which are less prone to revision, such as wage settlements or inflation expectations, could be a useful tool.

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34 See Deutsche Bundesbank, On the problems of macroeconomic imbalances in the euro area, Monthly Report, July 2010, pp 17-38, and Deutsche Bundesbank, Real economic adjustment processes and reform measures, Monthly Report, January 2014, pp 19-37.

35 For example, Bouis et al (2012) show that, with the exception of the United States, the negative output gaps recorded by the OECD for the major advanced economies at the current end are mainly due to the fact that actual total factor productivity (TFP) remained below potential TFP. As actual TFP is itself the residual of an estimate, however, Bouis et al consider uncertainty about potential TFP to be especially high. See R Bouis, B Cournède and A K Christensen (2012), Implications of Output Gap Uncertainty in Times of Crisis, OECD Economics Department, Discussion paper, No 977.