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The Information Content of Capacity Utilisation Rates for Output Gap Estimates

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Abstract

From a theoretical perspective, the output gap is probably the most comprehensive and convincing concept to describe the cyclical position of an economy. Unfortunately, for practical purposes, the concept depends on the determination of potential output, which is an inherently unobservable variable. In this paper, we examine whether the real-time estimates of the output gap as published by the OECD can be improved by referring to measures of physical capital capacity utilisation from business tendency surveys. These data relate directly to the stress on the current capacity to produce goods and services and are not revised. Our real-time panel data set comprises 22 countries at an annual frequency with data vintages from 1995 to 2009. We show that the real-time output gaps are informationally inefficient in the sense that survey data available in real time can help produce estimates that are significantly closer to later releases of output gap estimates.

JEL-Code: D24, E32, E37.

Keywords: output gap, capacity utilisation, real-time analysis, survey data.

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1. Introduction

Business cycles characteristically manifest themselves in over- or underutilisation of productive resources of an economy. Without those, an economy would continuously produce at potential. From a theoretical perspective, the output gap, which is defined as the relative deviation of observed output from potential output, is probably the most comprehensive and convincing concept to describe the cyclical position of an economy. And indeed, it is widely used amongst theorists as well as practitioners.

Unfortunately, for practical purposes, the concept depends on the determination of potential output, which is an inherently unobservable variable. The OECD, for instance, which is devoting considerable effort to deliver internationally comparable and timely estimates of the output gap, uses a macroeconomic production function approach, combined with a Hodrick-Prescott filter, to isolate trend productivity developments in order to quantify the potential output path and thereby the output gap. By including labour and capital, this approach is clearly more sophisticated than the often used univariate time-series approaches. However, it is well-known that also these output gap estimates are prone to large revisions over time (Koske and Pain 2008, Orphanides and van Norden 2002, Tosetto 2008). Hence, while the output gap might be a useful concept for theoretical thinking about, e.g., inflationary pressures *ex post*, its practical usefulness is severely impaired or even annihilated by the inherent difficulty to know with sufficient reliability the magnitude of the output gap at the time when the policy maker needs to know it, i.e., in real time.

Obviously, real-time uncertainty about the magnitude of the output gap is not merely a theoretical concern. There is evidence that reliance on the output gap might be responsible for some of the gravest central bank mistakes of the last decades, when real-time output gap measures failed to take account of changes in the growth rate of potential output. For instance, the discussion about the retarded effects of the IT revolution and the "jobless" recovery in the US points to the possibility of another major change in the growth rate of potential output,[1] and the extent to which the global 2008/09 recession that was triggered by the sub-

[1] As Kahn and Rich (2003) have pointed out, accepting the "new economy" story and assuming a sustainable acceleration of potential output growth would significantly lower our present real-time estimates of the output gap which tend to attribute fast growth to cycle rather than trend.

prime mortgage turmoil in the US will affect potential output in the years to come is now on the agenda.

In this paper, we follow the general approach of Jacobs and Sturm (2005, 2008) to examine whether real-time estimates of the output gap can be improved by referring to measures of physical capital capacity utilisation from business tendency surveys. To assess this question empirically, we construct a large panel data set, comprising 22 countries with annual data from vintages published between 1995 and 2009. It contains information on capacity utilisation and output gap estimates as published by the OECD in real time. We show that the real-time output gaps are informationally inefficient in the sense that survey data available in real time can help to produce estimates that are significantly closer to later releases of output gap estimates.[2]

The paper is organised as follows: After a discussion of the business cycle, its theoretical and empirical reflection in the output gap and the potential usefulness of business tendency surveys (Section 2), we discuss and describe our data (Section 3). Then, we present our empirical analyses (Section 4). The final section summarises and concludes.

2. The business cycle, the output gap and business tendency surveys

From a theoretical perspective, the output gap (defined as the relative deviation of the observed output, Y, at time t from potential output, Y^*, at that time: $g = (Y_t - Y^*_t)/Y^*_t$) is probably the most convincing concept to determine the cyclical position of an economy. It quantifies the over- or underutilisation of the productive resources of an economy. And indeed, it is widely used amongst practitioners. Moreover, it is a well-established theoretical concept in contemporary economics and plays a crucial role in many macroeconomic models. It is frequently and successfully referred to in research looking for a scheme to "explain" (reproduce) historical paths of central bank policy settings and it is probably safe to assume that a substantial number of monetary policy makers as well as fiscal authorities pay close attention to

[2] Trimbur (2009) is also exploring this issue. By focusing on the US only, he "investigate[s] the use of capacity utilization as an auxiliary indicator to improve on output gap estimates in real-time. … [He also] find[s] that this bivariate approach leads to significant gains in the accuracy of real-time estimates and in the quality of revisions."

real-time estimates and forecasts of the output gap.[3] As a matter of fact, it would be very hard to understand the behaviour of for instance the US Federal Reserve System without reference to the output gap.

Although the output gap plays such a prominent role in current economic theory and policy, it still is an inherently immeasurable, equilibrium-based construct. It refers to the deviation of realised from potential output in a constantly changing economic environment. Successfully estimating the output gap would require not only reasonably reliable data on current or near future *realisations* of economic activity (which are hard enough to get),[4] but also reasonably reliable estimates or projections of *potential* (*equilibrium*) output Y^*, which – like the business cycle – is an inherently unobservable variable.

Unsurprisingly thus, apart from a general understanding that the output gap denotes the relative departure of empirical output from its "equilibrium" or "potential", the current state of the art does not give a conclusive answer to how it should be conceptualised. We can distinguish (at least) three attempts at defining it: a substantive, a statistical and a functional:[5]

(1) The *substantive approach* argues that potential output is a function of the amount of the factors of production voluntarily[6] available at the period under consideration and the technology at hand to combine them to produce goods and services. This is clearly an economically meaningful concept, and – presumably – this is the basis for its popularity.[7] To implement it,

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[3] For example, the Swiss "debt break" (Eidgenössisches Finanzdepartement 2001) specifies the budget deficit (surplus) as a function of a Hodrick-Prescott filtered real-time output gap.

[4] Evidently, estimating potential output from unreliable estimates of real output is not likely to produce reliable estimates of output gaps.

[5] See also Chagny and Döpke (2001) and Dergiades and Tsoulfidis (2007).

[6] This needs to be stressed, since potential labour is not just a linear function of a well defined demographic cohort, but intrinsically endogenous, responding to a wide array of economic incentives, regulatory interventions, changing tastes (e.g., for leisure), labour force participation of women, consumption ingredients of prolonged education, etc. In addition, effective working hours directly affect the intensity with which the stock of physical (and other) capital is used, so that the effects of fluctuations in effective labour are further amplified.

[7] The neo-Keynesian representation is neatly verbalised by Nelson and Nikolov (2003): "… economic theory suggests … that potential output corresponds to the output level that would prevail in the absence of nominal wage or price rigidity."

however, is a formidable task; and while a number of attempts to estimate full capacity production functions have been conducted, some, if not most, of the results have been rather disappointing. Consequently, the substantive approach, to which the output gap owes much of its credit, is not the one that practical economists usually refer to.

(2) According to the *statistical* approach, potential output is what you get when you send a real GDP series through a low pass filter (frequently the Hodrick-Prescott filter) and relate it to the unfiltered series.[8] Many of the practical methods in use nowadays to derive estimates of potential output partly or wholly rely on this statistical approach of extracting a smooth trend from the historical path of the output series. The only theoretical notion behind this black box approach is that potential GDP is evolving along a path characterised by considerable inertia. However, if these methods do not predict a constant growth rate for potential output, but allow for some adaptation of potential to observed output, real-time output gap estimates are imperfect in the sense that they are, firstly, prone to revisions as new data keep coming in and, secondly, systematically biased in periods of structural change, since the trend is ultimately identified *ex post* by past *and* future realisations. Regrettably, this is true for linear time-invariant filters and band pass filters alike.[9]

(3) The *functional approach*: Potential output is the level of output at any point in time that results in zero inflationary pressure. This is sometimes labelled NAIRO ("non-accelerating-inflation rate of output")[10] and is conceptually related – but not identical – to the NAIRU ("non-accelerating-inflation rate of unemployment"). The difference between the two is that the first is based on the existence of an equilibrium potential output path, while the latter postulates an equilibrium rate of unemployment, but to the degree that there is a close relation between output and employment, the distinction between the two gets academic rather than practical.

Note that this appears like an elegant approach to overcome the practical difficulties with the substantive notion of the output gap. If theory tells you that a positive (negative) output gap

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[8] Of course, this is not a very useful definition (like saying GDP is what is published by the Statistical Office), but in the end it is not completely without sense, because this is how Y^* is frequently computed.

[9] For an elaboration of this point, see van Norden (2002).

[10] See Hirose and Kamada (2003).

creates inflationary (deflationary) pressure and/or over-employment (underemployment) of the factors of production, why not use this theoretical link to identify the output gap inductively by looking at inflationary and/or factor market pressures?[11] Find the points in time when inflationary pressure was zero – e.g., realised inflation (π) equalled expected inflation (π^e) – and/or the points in time when unemployment/capacity utilisation was equal to "equilibrium" – e.g., some longer term average of their past realisations –, and you have identified periods where "functional" potential output equalled observed output. Then, specify functional relationships between the output gap and inflationary pressure and/or unemployment/excess capacity utilisation. Finally, collect data on your indicators and refer to the functional relationships to derive a quantitative measure of the output gap. And indeed, so-called "multivariate filters" that amend the univariate low pass filter approach with additional information, are not uncommon.[12]

However, there are two caveats. Firstly, to incorporate additional indicators for strain on resources into GDP centred estimates of the output gap, they themselves have to be formulated in gaps.[13] In other words, to help gauge the "unobservable" potential output a range of other "unobservables", e.g., the NAIRU and/or "desired" or "equilibrium" capacity utilisation are referred to. Hence, the problem of not being able to measure potential output directly translates into the problem of quantifying the NAIRU[14] and/or "equilibrium" capacity utilisation. The improvement in the augmented output gap measure is therefore subject to the validity of the approaches to estimate the "second order" unobservables. Secondly, potential output is now partly endogenised. Specifically, to the extent that the additional information dominates the output gap estimate, this approach reverses the theoretical relationship "*output gap* $\rightarrow$ *in-*

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[11] See Laxton and Tetlow (1992) for the seminal contribution for this approach.

[12] In particular, a number of central banks, e.g., the Bank of Canada, the Reserve Bank of New Zealand and the Reserve Bank of Australia refer to "multivariate filters".

[13] Laxton and Tetlow (1992), Butler (1996). The Reserve Bank of New Zealand's approach follows the same logic. See Conway and Hunt (1997).

[14] For a fundamental critique of the NAIRU see Hagger and Groenewold (2003). Evidence for the practical usefulness of a Phillips curve relationship to forecast inflation is mixed. For example, Gruen et al. (2005) report encouraging evidence from Australia, whereas Robinson et al. (2003) point to difficulties with real-time estimates and Lansing (2002) argues that it is of little or no use for the USA.

flationary pressure" into an inductive measurement model "*inflationary pressure → output gap*", thereby depriving the output gap concept of most of its original substantive content. With potential output being identified contingent on observed inflation and/or inflationary pressure, one can no longer claim that the correlation between such an output gap measure and observed inflation represents a structural relationship. It is there by construction.[15] Hence, with such a functional measurement approach, the output gap loses some of its original sense and should properly rather be regarded as an econometric indicator of inflationary pressure.

To summarise, the potential output path Y^*_t should ideally be quantified referring to a full-blown production function (substantive approach). Since this is a formidable task, it is common to refer to either to univariate statistical procedures – filters – that are designed to isolate the trend of the Y_t series from the cycle (and the noise) or to eclectic approaches such as "multivariate filters" and then to interpret this trend as Y^*_t. Various filters are doing the job fairly well, and the statistical approach impresses through its simplicity. The assumption that the univariate output trend corresponds to potential output, however, suffers from the fact that it ignores all other information that could lead to a reassessment of the potential. Exogenous shocks or technological developments which may lead to persistent level changes of the potential are ignored, as are changes to the stock of accumulated factors of production (physical and human capital) due to changes to net investment ratios. The last point is particularly critical: while shocks to observed output – which are filtered out by a low pass filter – rightly appear as deviations from potential, technical change or evolution of the economy's capital stock are not duly considered when determining potential output with a low pass filter, which would identify them as cyclical.

Hence, it is not a surprise that serious doubts have been expressed as to whether the output gap is a *practically useful* concept. In two seminal papers Orphanides and van Norden (2002, 2003) argue and illustrate empirically that while the output gap might be a useful concept for theoretical thinking about inflationary pressures, and while in addition to this, this usefulness is empirically well-established *ex post*, its practical usefulness is severely impaired or even

[15] This circularity can be traced to the very origins of multivariate filtering; see Laxton and Tetlow (1992: i): "… if movements of potential output have a different effect on inflation than do cyclical movements in output, then information on inflation may be useful in identifying potential output."

annihilated by the inherent difficulty to know with sufficient reliability the magnitude of the output gap at the time *when the policy maker needs to know* it, i.e., in *real time*. Specifically, we are confronted with the "endpoint problem", which reflects the fact that without knowledge of the future, it is impossible to distinguish between cycle and trend, so that when shifts of the latter are eventually discovered, prior estimates of potential output have to be revised.

This view is supported by a large body of empirical evidence, which also suggests that the endpoint problem associated with the output gap may already have led to severe misjudgements and resulting policy mistakes that only become clear in hindsight. Notably, Orphanides (2003, p. 997) compares a reconstructed real-time output gap series for the US going back to 1951 with today's view and finds persistent underestimation through most of the period until the mid-eighties. In the mid-seventies, the misperception amounted to an incredible *ten percentage points* of potential output, which, in a simulated real-time Taylor rule framework, would suggest that the Fed's monetary policy during the "Great inflation" was by no means meant to be permissive. Similarly, Nelson and Nikolov (2003) reconstruct a real-time output gap series for the UK going back to 1965 and plug this into a standard monetary policy framework. They find that the Bank of England's failure to lean against inflation in the early 1970s can be attributed to a real-time perception of the output gap that was *seven percentage points* lower than what one would quantify it now with the benefit of hindsight. Cayen and van Norden (2002) conduct a similar analysis for Canada since 1981 and find revisions of up to *six percentage points* of potential GDP.[16] For Japan, Hirose and Kamada (2003) find that since 1995 an output gap which is derived by a Hodrick-Prescott filter augmented with a Phillips curve relationship would have suffered revisions of the same magnitude. Analysing real time quarterly output gap estimates resulting from the Reserve Bank of New Zealand's multivariate filter starting in 1997, Graff (2004) finds that the average total revision after three years was close to one percentage point, which may appear low compared to other fig-

[16] While Cayen and van Norden (2002) evaluate a wide range of output gap estimation methodologies, they lamentably do not include the Bank of Canada's multivariate filter. They note (p. 58) that this would be "interesting". The reason for this omission is probably that the Bank of Canada's multivariate filter was only installed in the mid-nineties, and whereas the other methodologies allow for "backcasts" to the beginning of the 1980s, the multivariate filter cannot easily be simulated. Note that the same is true for the Reserve Bank of New Zealand's multivariate filter.

ures, but nevertheless implies a massively distorted signal for the conduct of monetary policy. He also shows that data revisions account for less than 7 percent of the cumulated revisions within three years from the monitoring quarter. Accordingly, the absence of official GDP data in real time is not the main cause for output gap revisions – the blame falls on the endpoint problem proper.[17] An analysis for Finland (Billmeier 2006) finds that out of nine output gap measures none would add significantly to a univariate autoregressive explanation of annual CPI inflation from 1980–2002 and attributes this to the fact that a "statistically satisfying measure of potential output" might not be feasible for a high volatility observed (yearly) output series like the Finnish one (p. 27). Bernhardsen et al. (2008) confirm the finding that data revisions are only responsible for a small fraction of total output gap revisions in Norway; and show that Norwegian real time output gap estimates are even less reliable than for the US. Furthermore, Cuche-Curti, Hall and Zanetti (2008) focus on the problem of estimating output gaps in Switzerland. They find that revisions in estimated output gaps are large, that they are potentially important for monetary policy, and that GDP mismeasurement contributes to output gap revisions.

The empirical literature thus casts serious doubt on the practical usefulness of the prevailing output gap measures in *real time.* When information on the state of the economy is most important, estimates of the output gap are to be uncomfortably unreliable; and this includes gaps resulting from multivariate filtering.[18]

What lessons can we learn from this? In our view, apart from a serious warning to take real-time estimates of the output gap with more than just a grain of salt, the importance of the output gap merits devoting more effort to improve the lamentable real-time characteristics of its prevailing empirical implementations. In particular, we shall now turn to some information that – to the best of our knowledge – has so far not been systematically exploited to improve output gap estimates in real time, which is the assessment of the degree of capacity utilisation by firms as reflected in business tendency survey.

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[17] This observation highlights the important – but frequently ignored fact – that the first official quarterly GDP releases (in New Zealand and elsewhere) are estimates, and as such not intrinsically more valid or precise than estimates produced by other researchers or institutions. It is tempting, but misguided to interpret the label "official" as "true".

[18] See also e.g., Gruen at al. (2005), Orphanides and van Norden (2002) and Rünstler (2002).

Business tendency surveys are nowadays conducted in a considerable and increasing number of countries. For our purpose, they are invaluable, as they reflect unique information on technical capacity. In particular, many surveys ask a quantitative estimate of the firm's rate of capacity utilisation in percent, which is the information we shall resort to in this paper.

The capacity utilisation rate that can be inferred from these surveys is an important business cycle indicator, as it relates directly to the stress on the current capacity to produce goods and services. From a policy perspective, technical bottlenecks indicate a positive output gap, whereas idle capacity above normal would have it negative. Yet, it is not obvious which capacity utilisation rate should be regarded as normal. Moreover, the level of normal capacity utilisation can change over time. When the substitutability of physical capital declines, firms will tend to keep more idle reserves to make sure they can cope with unexpected orders. On the other hand, with technical and organisational progress making production more flexible, the normal rate of capacity utilisation could increase. In a similar fashion, a move towards just-in-time production could lift the normal rate of capacity utilisation. These reflections imply that the rate of capacity utilisation is not necessarily a stationary variable. Moreover, due to the ambiguity of the theoretical predictions, it is not clear whether we should expect an increase or a decline in the level that is considered normal over time.[19]

Accordingly, although business tendency surveys deliver highly relevant and timely information on firms' self assessment of the stress on their technical capacities, they cannot be used directly to compute economy-wide measures of capacity utilisation. However, this information could be extremely useful to add confidence to timely estimates of the output gap, as business tendency survey data are usually not revised; they are final as soon as a survey is completed.

In what follows, we shall demonstrate that the above conjecture is reflected in the real-time data. In particular, we show that some important and widely circulated output gap estimates – those published bi-annually by the OECD – are indeed informationally inefficient in the sense that survey data available in real time can contribute to produce estimates that are closer to the final values.

[19] See e.g., Shapiro et. al. (1989), Bansak et al. (2007) and Etter et al. (2008).

3. Data

We refer to a panel data set, comprising 22 countries from 1995 to 2009 (lengths depending on the particular series and country) on output gap estimates as published by the OECD in real time and quantitative information on capacity utilisation from business tendency surveys using various sources.

The business tendency survey data on capacity utilisation are in general published quarterly and each time relate to the just-starting quarter. The OECD output gap estimates are released bi-annually and relate to years and contain back-, now- and forecasts. The OECD started to release annual output gap estimates in December 1995.[20]

Capacity utilisation

Our key explanatory variable – capacity utilisation as reflected in business tendency surveys – belongs to the core items of the EU harmonised business tendency surveys as collected and published by the Economics and Financial Affairs division of the European Commission. Furthermore, many other advanced economies conduct surveys including similar questions.[21] The item that we refer to is quantitative, asking respondents to assess the level of capacity utilisation of their firm in percent.[22] The relevant question is posed in surveys generally carried out during the first month of the quarter to which is referred to, i.e., January, April, July and October. Roughly at the turn of the month, i.e., before mid-quarter, the results are made public. Data for non EU-members countries were first of all taken from the OECD Main

[20] In addition to the yearly data, the OECD started publishing quarterly output gap data in December 2003. Thus, the annual data cover a much longer time span and therefore contain more turning points. Moreover, quarterly GDP data – which are the basis on which quarterly output gap estimates are built – are sometimes of questionable quality (see Agénor et al., 2000). They are often obtained from a quarterly breakdown of yearly aggregates from national accounts with help of quarterly indicators. The quarterly pattern, which is to some degree arbitrarily imposed on the yearly aggregates, then accounts for a major share of the series' variance. Annual data do not suffer from this problem. Hence, we opt to conduct our analysis with annual data.

[21] See http://ec.europa.eu/economy_finance/db_indicators/surveys/partner_institutes/index_en.htm and https://www.ciret.org/idc/synoptic/ .

[22] The exact formulation in the harmonised EU survey is: "At what capacity is your company currently operating (as a percentage of full capacity)? The company is currently operating at □□.□ % of full capacity."

Economic Indicators.[23] A limited amount of data was taken from other sources than the European Commission or the OECD.[24]

For our purposes, an important characteristic of the survey data is that they are usually not revised, but final as soon as a survey is completed.[25] Yet, even if the original data are not revised, we have to be aware of an endpoint problem in the seasonally adjusted published data: Seasonal filtering may lead to gradual revisions as new data points are added and the computed seasonal factors change along with the sample period.[26] Hence, our analysis starts by using unfiltered capacity utilisation data only.[27]

The unfiltered data are not affected by the endpoint problem. Nevertheless, as some survey data are heavily affected by season and noise, it may be necessary to eliminate seasonal pat-

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[23] See "Leading Indicators and Tendency Surveys", http://www.oecd.org.

[24] For Belgium, we collected non-seasonally adjusted capacity utilisation rates for it manufacturing industry from the National Bank of Belgium. For Japan, unadjusted operating ratios in the Japanese industry come from METI Ministry of Economics, Trade and Industry. In case of New Zealand, non-seasonally adjusted capacity utilisation rates in the manufacturing and construction were kindly provided by the New Zealand Institute of Economic Research (NZIER) The last ten observations for Australia were taken directly from the National Australia Bank survey, see .
http://www.nab.com.au/wps/wcm/connect/nab/nab/home/business_solutions/10/1/5#archive

[25] Revisions may occur when early information is taken from a sub-sample of respondents while the survey is not yet completed. Completion from there on, however, is usually only a question of a few days, so that published survey data are usually final.

[26] While seasonal adjustment can in principle be performed with constant seasonal factors, thus avoiding subsequent revisions, this is the exception rather than the rule. Most standard procedures to eliminate season rely on recursive or rolling estimates of seasonal factors, and noise is also addressed, e.g., via outlier detection or moving averages. Accordingly, what is called "seasonal adjustment" to some degree amounts to outright low pass filtering where the endpoint problem of symmetric filters is severe and can lead to massive subsequent revisions.

[27] Consequently, we had to exclude Canada, Greece and the United States from our sample, for which only seasonally adjusted data are available. Furthermore, both in Canada and in the United States the reported quarterly capacity utilisation rates are constructed using seasonally adjusted GDP data and are therefore prone to the same revisions as the GDP data. For Austria, the Czech Republic, Finland and Italy, where the published statistics do not report not seasonally adjusted capacity utilisation series either, we received the unadjusted series upon request from following institutions, which is here thankfully acknowledged: Austria: WIFO, Czech Republic: Czech Statistical Office, Finland: Confederation of Finnish Industries EK; Italy: ISAE.

terns and increase the signal-to-noise ratio to extract information on the cyclical position of an economy. By taking the average over four quarters to aggregate the capacity data to an annual frequency, this is not posing a problem in our set-up.

Output gap

Considering the variety of techniques to estimate output gaps, the choice of how to specify our dependent variable is based on economic as well as pragmatic reasons. For the purpose of this paper, the preferred output gap estimates should either have a sufficiently long and documented history or else be computed in a way to enable us to reconstruct vintages of real time data that are comparable across time and countries. Hence, the two feasible options are either to find reasonably sophisticated estimates that have a history which is well enough documented, or to refer to real-time vintages of GDP only and compute output gap estimates based on univariate methods, e.g., with a low-pass filter. The latter approach would result in output gap vintages that consider nothing apart from GDP and admittedly suffer from a well-known endpoint problem. Hence, it would not be very surprising to find that one could have done better than this in real time. We therefore prefer to refer to published data that are based on a unifying framework which goes beyond a univariate approach.

The output gap data corresponding closest to our requirements are those of the OECD.[28] According to the documentation given in the OECD Economic Outlook, its estimates are usually based on multivariate techniques with reference to economic theory:[29]

> "The output gap is measured as the percentage difference between actual GDP in constant prices, and estimated potential GDP. The latter is estimated using a production function approach for all countries except Portugal, taking into account the capital stock, changes in labour supply, factor productivity and underlying non-accelerating

[28] Also the IMF publishes in its World Economic Outlook output gap data for advanced economies. See De Masi (1997) for a description. However, the country coverage by the IMF is less than that of the OECD, and the IMF output gap series obviously suffer from severe endpoint problems at the left margin of the series (e.g., for Belgium, the April 2009 IMF output gaps are consistently above 10% for 1980–1995, which does not make any sense; similar problems are encountered for Finland, Italy and New Zealand). Accordingly, we did not construct a real-time database using IMF output gap releases.

[29] This text is now found in every issue of the OECD Economic Outlook, along with reference to Giorno et al. (1995).

> wage rates of unemployment or the NAWRU for each Member country. Potential output for Portugal is calculated using a Hodrick-Prescott filter of actual output."[30]

In a nutshell, the OECD estimates a production function using capital and labour and applies a Hodrick-Prescott filter on the residuals which are then interpreted as the trend in multifactor productivity. Together with an estimate of potential employment – based on an estimated non-accelerating wage rate of unemployment – this is plugged back into the production function to result in an estimate of potential output.[31]

Vintages of the OECD output gap estimates are documented since 1995, and the cross-sectional coverage corresponds roughly to the OECD member countries, so that reconstruction of a reasonably large real time panel is possible. The estimates are released bi-annually at the occasion of the publication of the OECD Economic Outlook in June and December. They relate to years. Annual output gap estimates started to be included in the OECD Economic Outlook from No. 57 onward, i.e., in December 1995. Our output gap data are exclusively obtained online via "Source OECD".[32]

The output gaps as published by the OECD contain back-, now- and forecasts. As noted by Tosetto (2008, p. 7), "it is impossible to […] separate estimates from projections." Furthermore, we ultimately want to check whether business tendency survey results can help improve output gap estimates in real time. Given this objective, we opt to concentrate on improving the estimate of that output gap observation for which survey results are already avail-

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[30] The inclusion of Portugal in our sample is not affecting any of our results in any quantitatively meaningful way.

[31] Given that we are going to use a panel data framework, it is important that the data generating process of the output gap measures is largely uniform across countries. Given that output gap revisions are much larger in magnitude than revisions to real GDP, the major reason for output gap revisions appear to lie in the construction of potential output.

[32] In August 2008, the OECD released a real-time database of its output gap estimates (OECD Quarterly output gap revisions database, August 2008). For documentation, see Tosetto (2008). However, the online data cover considerably more data points than the real-time database as published by the OECD for the same set of OECD Economic Outlook issues. Furthermore, our database includes information up to the OECD Economic Outlook No. 86 (December 2009). Hence, by using "Source OECD" we were able to construct a broader and longer real-time panel.

able, i.e., for which survey results could have been used in producing the output gap estimate for that year.

Given the release dates and reference quarters of capacity utilisation rates, together with the bi-annual publication rhythm of the output gap data, we therefore define as "real time" the annual estimate of the output gap that is published in December of that year.[33] The June release of the same year is considered to be a two quarters ahead forecast, the June release of the following year is the first revision after two quarters, and so on.

[Insert Figure 1 about here]

The OECD output gap data release and revision sequence is illustrated in Figure 1. Referring to countries only, for which we were able to collect not seasonally adjusted capacity utilisation data from business tendency surveys, the output gap vintages to be analysed comprise a maximum of 22 countries. The sample is documented in Table 1.

[Insert Table 1 about here]

Some descriptive statistics

Before proceeding to the regression analysis, we first turn our attention to the above-described raw data. They are summarised in Table 2. The left-hand side of this table refers to all available observations (restricted by the availability of the output gap and capacity utilisation), the right-hand side restricts the sample to the largest fixed set of countries and time frame possible for which the first eight releases of the output gap estimates and the capacity utilisation rate (as our main explanatory variable) are available.

[Insert Table 2 about here]

Across countries and over time, the average capacity utilisation rate equals approximately 81.5 percent. With respect to the output gap, Table 2 reveals that – for the sample period analysed – the estimates of the output gap have on average increased across the different releas-

[33] Another potential criterion could have been to focus on that reference year for which official GDP data rather than OECD estimates are available when releasing of the output gap estimates, which is usually two quarters after the "monitoring" quarter (chronological real time). Given the findings reported above (see footnote 17) and given that our focus is on the usefulness of survey data and the need for policymakers to have real time nowcasts, we do not opt for this. (The qualitative results are not affected by this choice.)

es. This suggests an upward bias in the revisions. To explore this further, Table 3 reports descriptive statistics on the revision process of output gap estimates.

[Insert Table 3 about here]

In the balanced sample, already the second release (Revision 1) represents an upward revision of on average about 0.15 percentage points. This is significantly different from zero and robustly so across our samples. Furthermore, the underlying individual revisions are on average all positive, mostly significant and do not show an obvious decline (not shown).[34] All this leads to a continuous increase in cumulative revisions over time.

When looking at the evolution of the mean of the *absolute* revisions we also do not see any clear evidence that the revision process on average tends to ebb off (not shown). Not even after more than ten years do absolute revisions come close to converging to zero (not shown). This makes it difficult to identify a particular release that has settled enough to serve as a benchmark. Hence, we have to resort to another criterion. We opt to look at the distribution of the revisions. As can be seen from Table 3, when cumulating the revisions of annual estimates, its distribution starts to look normal after seven revisions, i.e., after 3½ years of revisions. To ensure that sample size remains decent, we stop our analysis after the eighth release, i.e., after seven consecutive revisions.

On average, this eighth release of the annual gap is more than 0.65 percentage points higher than the first release. Looking at the variation and extremes of revisions shows that these can be considered to be of an almost similar magnitude as the actual output gap estimates themselves.[35]

4. Regression results

The regression analysis aims at showing whether OECD output gap estimates could have been improved in real time when resorting to survey data on capacity utilisation. By improvement, we mean that the modified estimates are closer to later releases of the same se-

[34] However, the correlation coefficients between the different revisions are mostly negative and hardly ever significant. Hence, we do not observe positive autocorrelation in the revision process.

[35] This point was already made by Orphanides and van Norden (2002). However, they only look at US data. Apparently this is a more general characteristic of output gap estimates.

ries. Hence, our working assumption is that revisions bring the estimates closer to the true values.

In recent years, modelling data revisions has been the subject of extensive research. Most of the time, the debate centred around the question whether data revisions are best modelled as 'news' or 'noise'.[36]

Ideally, early (first) estimates of the output gap ($y_{R1}(i,t)$) in country i would incorporate all information about period t available at that moment. In this case, any subsequent releases of the output gap ($y_{Rx}(i,t)$, where $x > 1$) would only differ from previous ones to the extent that new information has become available in the meantime. This implies that under this 'news' hypothesis revisions are orthogonal to the first release and hence not predictable:

$$(1) \qquad y_{Rx}(i,t) = y_{R1}(i,t) + \varepsilon(i,t), \qquad \text{cov}(y_{R1}(i,t),\varepsilon(i,t)) = 0$$

At the other extreme, revisions might be due to the fact that the underlying true value is initially measured with noise. In that case, revisions are uncorrelated to the true value:

$$(2) \qquad y_{R1}(i,t) = y_{Rx}(i,t) + \eta(i,t), \qquad \text{cov}(y_{Rx}(i,t),\eta(i,t)) = 0$$

Our hypothesis is that these first estimates are informationally inefficient in the sense that survey data on capacity utilisation ($CU(i,t)$) available in real time can help produce estimates that are significantly closer to later releases of the output gap. To test this, we estimate the following panel-data version of the Mincer-Zarnowitz (1969) test for forecast efficiency, i.e., the noise specification:

$$(3) \qquad \Delta_{Rx\text{-}R1}y(i,t) \equiv y_{Rx}(i,t) - y_{R1}(i,t) = \alpha(i) + \beta(t) + \gamma \cdot y_{R1}(i,t) + \delta \cdot CU(i,t) + v(i,t).$$

Fixed country-specific effects are captured by $\alpha(i)$. Furthermore, and in contrast to the usual time-series based literature on revisions, we add fixed time-specific effects, $\beta(t)$, to capture the influence of the world business cycle and other international shocks on the revision process. The noise term is represented by $v(i,t)$. By construction, this error term is autocorrelated up to the order $(x–2)$. For this reason, we estimate the above equation using Newey-West

[36] See, e.g., Boschen and Grossman (1982), Mankiw, Runkle and Shapiro (1984), Mankiw and Shapiro (1986), Maravall and Pierce (1986), Mork (1987, 1990), Patterson and Heravi (1992), Croushore and Stark (2001, 2003), Faust, Rogers and Wright (2005), Swanson and Van Dijk (2006), Aruoba (2008), Fixler and Nalewaik (2009), and Jacobs and Van Norden (2010).

standard errors correcting for (heteroskedasticity and) autocorrelation up to lag (x–2).[37] A necessary condition for the first releases to be informationally efficient is that the parameter estimates of γ and δ are not (significantly) different from zero. This is what we shall subsequently concentrate upon.

[Insert Table 4 about here]

We estimate Equation (3) for all releases up to release 8. Table 4 summarises the regression results for increasing revision horizons. While the upper half of the table refers to all available observations, the lower half concentrates on a strictly balanced sample. The conclusions are robust to the choice of sample. In each half, the bottom part presents some diagnostics tests. In line with Equation (3), the regressions include country-fixed and time-fixed effects. Statistically, this appears the most warranted panel specification. Likelihood ratio tests show that there is clear evidence for joint significance of both country and time fixed effects. The first release, i.e., our coefficient estimate of γ, is highly significant and negative. Although we find a general upward bias with respect to the revisions, this effect works in the opposite direction. An initially high value of the output gap is more likely to be revised downward than an initially lower value. In line with our hypothesis, high values of the capacity utilisation rate in the year to which the data refers imply subsequent upward revisions. What is quite striking is the general increase of the adjusted R^2 over the revision horizon. The further away the actual release, the better our model – using only information available at the time of the first release – performs.

[Insert Figure 2 about here]

This is highlighted in Figure 2. It depicts the resulting adjusted R^2 using a strictly balanced sample both with and without inclusion of our capacity utilisation rate. Except for the first revision, the adjusted R^2 improves substantially by including the capacity utilisation rate. Furthermore, the goodness of fit increases as time passes, i.e, our model is able to explain larger parts of later releases as compared to earlier ones at the moment of the first release. From the fifth cumulative revision onwards, our model is able to explain between 40 and 50 percent of

[37] Note that because the time dimension relevant for the econometrics is the period the data refer to (t) and not the period the data is published, $y_{R1}(i,t)$ is not a classical lagged dependent variable and therefore we do not have a so-called Nickell (1981) bias in this panel set-up.

the revisions. The corresponding fraction is much lower for the first couple of revisions. As we are ultimately interested in the "final" value of the output gap, this speaks in favour of our estimation strategy and against the hypothesis that revisions in output gap data are driven by newly released information, i.e., 'news'.

As the results with respect to the capacity utilisation rate are – with the exception of the first revision – qualitatively very similar across the revision horizon, we concentrate on the last release as compared to the first, i.e., the seventh cumulative revision. Table 5 summarises the regressions results. Column (1) shows the result without the capacity utilisation rate; in column (2) it is included. As a consequence, the estimated γ-coefficient becomes more negative, showing that especially when corrected for the reported capacity utilisation, the mean-reversion tendency in the revision process is quite strong. The capacity utilisation coefficient is positive and significant: in case the utilisation rate is one percentage point above average, the output gap estimates are subsequently on average revised upward by about 0.16 percentage points of potential GDP. Given the generally acknowledged lead of the manufacturing sector in the business cycle, we test whether the lag of the capacity utilisation rate is also significant (column (4)).[38] We find that not only the contemporaneous capacity utilisation rate is significant, but also its one year lagged version. By including both, we arrive at the statistically strongest specification, i.e., with the highest adjusted R^2 (column (5)).

5. Concluding remarks

The output gap might be a useful concept for theoretical thinking about inflationary pressures *ex post*; its practical usefulness is severely impaired or even annihilated by the inherent difficulty to know with sufficient reliability the magnitude of the output gap at the time when the policy maker needs to know it, i.e., in real time. We show that this verdict holds for the annual OECD output gap estimates, which are in general massively revised. Moreover, as revisions tend to continue for prolonged periods, it remains hard to reliably quantify the output gap for a particular period, even with the benefit of hindsight.

In this paper, we examine whether the real-time estimates of the output gap can be improved by referring to measures of physical capital capacity utilisation from business tendency sur-

[38] To allow better comparison, in Column (3) the sample is restricted to be the same as in Column (4) but includes the contemporaneous value of the capacity utilisation rate.

veys. These are highly informative data, as they relate directly to the stress on the current capacity to produce goods and services. Moreover, and importantly in our context, these data are usually not revised, so that they are not affected by the endpoint problem.

To assess this question empirically, we construct a large panel data set, comprising up to 22 countries with yearly data using qualitative and quantitative information on capacity utilisation as collected in business tendency surveys and output gap estimates as published by the OECD in real time. We show that the real-time output gaps are informationally inefficient in the sense that survey data available in real time can help to produce estimates that are significantly closer to later releases of output gap estimates. Starting from this, future research will have to show how these findings can be used to improve output gap estimates in real time.

References

Agénor, P.-R., C.J. McDermott and S.P. Eswar (2000), "Macroeconomic Fluctuations in Developing Countries: Some Stylized Facts", World Bank Economic Review, 14, 251–285.

Aruoba (2008), Aruoba, and S. Boragan (2008), "Data revisions are not well behaved", Journal of Money, Credit and Banking, 40, 319–340.

Bansak, C.A., N.J. Morin and M.A. Starr (2007), "Technology, Capital Spending, and Capacity Utilization", Economic Inquiry, 45:3, 631-645.

Bernhardsen, T., Ø. Eitrheim, A.S. Jore and Ø. Røisland (2005), "Real-time data for Norway: challenges for monetary policy", North American Journal of Economics and Finance, 16, 333–349.

Billmeier, A. (2006), "Measuring a Roller Coaster: Evidence on the Finnish Output Gap," Finnish Economic Papers, 19:2, 69-83.

Boschen, J.F. and H.I. Grossman (1982), "Test of Equilibrium Macroeconomics Using Contemporaneous Monetary Data", Journal of Monetary Economics, 10, 309-333.

Butler, L. (1996), A Semi-Structural Method to Estimate Potential Output: Combining Economic Theory with a Time-Series Filter, Bank of Canada Technical Report No. 77.

Cayen, J.-P. and S. van Norden (2002), La fiabilité des estimations de l'écart de production au Canada, Bank of Canada Working Paper 2002–10.

Chagny O. and J. Döpke (2001), Measures of the Output Gap in the Euro-Zone: An Empirical Assessment of Selected Methods, Kiel Working Paper No. 1053.

Conway, P. and B. Hunt (1997), Estimating Potential Output: a Semi-structural Approach, Reserve Bank of New Zealand Discussion Paper G97/9.

Croushore, D. and T. Stark (2001), "A real-time data set for macroeconomists", Journal of Econometrics, 105, 111-130.

Croushore, D. and T. Stark (2003), "A real-time data set for macroeconomists: Does the data vintage matter?", Review of Economics and Statistics, 85, 605-617.

Chuche-Curti, N., P. Hall and Zanetti, A. (2008), "Swiss GDP Revisions: A Monetary Policy Perspective", Journal of Business Cycle Measurement and Analysis, 2008:2, 183-213.

De Masi, Paula R. (1997), IMF Estimates of Potential Output: Theory and Practice, IMF Working Paper No. 97/177.

Dergiades T. and L. Tsoulfidis (2007), "A New Method for the Estimation of Capacity Utilisation: Theory and Empirical Evidence from 14 EU Countries", Bulletin of Economic Research, 59:4, 361–381.

Eidgenössisches Finanzdepartement (2001), Die Schuldenbremse. Dokumentation, 2nd ed., Bern (www.efd.admin.ch/dokumentation/gesetzgebung/00573/00869/index.html?lang=de).

Etter, R., M. Graff and J. Müller (2008), Is "Normal" Capacity Utilisation Constant over Time? Analyses with Macro and Micro Data from Business Tendency Surveys, 29th CIRET Conference 2008, Santiago de Chile, 8–10 October.

Faust, J., J.H. Rogers and J.H. Wright (2005), "News and noise in G-7 GDP announcements", Journal of Money, Credit, and Banking, 37, 403-419.

Fixler, D.J. and J.J. Nalewaik (2009), News, Noise, and Estimates of the "True" Unobserved State of the Economy, mimeo.

Giorno C., P. Richardson, D. Roseveare and P. van den Noord (1995), "Potential Output, Output Gaps and Structural Budget Balances", OECD Economic Studies, 24, 167-209.

Graff, M. (2004), Estimates of the output gap in real time: how well have we been doing? Reserve Bank of New Zealand Discussion Paper DP2004/04, Wellington, May 2004.

Gruen, D., T. Robinson and A. Stone (2005), "Output Gaps in Real Time: How Reliable are they?" Economic Record, 81:252, 6-18.

Hagger, A. J. and N. Groenewold (2003), "Time to Ditch the Natural Rate?", Economic Record, 79, 324–335.

Hirose, Y. and K. Kamada (2003), A New Technique for Simultaneous Estimation of Potential Output and the Phillips Curve, Bank of Japan Monetary and Economic Studies, August 2003.

Jacobs, J.P.A.M. and J.-E. Sturm (2005), "Do ifo indicators help explain revisions in German industrial production?", in Ifo Survey Data in Business Cycle and Monetary Policy Analysis, editors J.-E. Sturm and T. Wollmershäuser, Physica Verlag, 93-114.

Jacobs, J.P.A.M. and J.-E. Sturm (2008), The information content of KOF indicators on Swiss current account data revisions, Journal of Business Cycle Measurement and Analysis, 4:2, 163-183.

Jacobs, J.P.A.M. and S. Van Norden (2010), Modeling Data Revisions: Measurement Error and Dynamics of "True" Values, mimeo.

Kahn, J. A. and R. Rich (2003), Tracking the New Economy: Using Growth Theory to Detect Changes in Trend Productivity, Federal Reserve Bank of New York Staff Reports No. 159.

Koske I. and Pain N. (2008), The usefulness of output gaps for policy analysis, OECD Economics Department Working Papers No. 621.

Lansing, K. (2002), Can the Phillip Curve Help Forecast Inflation? Federal Reserve Bank of San Francisco Economic Letter No. 2002–29.

Laxton, D. and R. Tetlow (1992), A Simple Multivariate Filter for the Measurement of Potential Output, Bank of Canada Technical Report No. 59.

Mankiw, N.G. and M.D. Shapiro (1986), "News or noise: An analysis of GNP revisions", Survey of Current Business, 66, 20-25.

Mankiw, N.G., D.E. Runkle and M.D. Shapiro (1984), "Are preliminary announcements of the money stock rational forecasts?", Journal of Monetary Economics, 14, 15-27.

Maravall, A. and D.A. Pierce (1986), The transmission of data noise into policy noise in U.S. monetary control", Econometrica, 54, 961-980.

Mincer, J. and V. Zarnowitz (1969), "The evaluation of economic forecasts," in: Economic Forecasts and Expectations, J. Mincer (ed.), New York: NBER.

Mork, K.A. (1987), "Ain't behavin': Forecast errors and measurement errors in early GNP estimates", Journal of Business & Economic Statistics, 5, 165-175.

Mork, K.A. (1990), "Forecastable money-growth revisions: A closer look at the data", Canadian Journal of Economics, 23, 593-616.

Nelson, E. and Nikolov, K. (2003), "UK Inflation in the 1970s and 1980s: the Role of Output Gap Mismeasurement", Journal of Economics and Business, 55:4, 353–370.

Nickell, S.J. (1981), "Biases in Dynamic Models with Fixed Effects", Econometrica, 49, 802-816.

Orphanides, A. (2003), "Historical Monetary Policy Analysis and the Taylor Rule", Journal of Monetary Economics, 50:5, 983–1022.

Orphanides, A. and S. van Norden (2002), "The Unreliability of Output-gap Estimates in Real Time", Review of Economics and Statistics, 84, 569–583.

Orphanides, A. and S. van Norden (2003), The Reliability of Inflation Forecasts Based on Output Gap Estimates in Real Time, www.hec.ca/pages/simon.van-norden/wps/RT2JMCB2.pdf.

Patterson, K.D. and S.M. Heravi (1992), "Efficient Forecasts or Measurement Errors? Some Evidence for Revisions to the United Kingdom Growth Rates", Manchester School of Economic and Social Studies, 60, 249-263.

Robinson, T., A. Stone and M. van Zyl (2003), The Real-Time Forecasting Performance of Phillips Curves Reserve Bank of Australia Research Discussion Paper 2003–12.

Rünstler, G. (2002), The Information Content of Real-Time Output Gap Estimates: An Application to the Euro Area, ECB Working Paper No. 182.

Shapiro, M.D., R.J. Gordon and L.H. Summers (1989), "Assessing the Federal Reserve's Measures of Capacity and Utilization", Brookings Papers on Economic Activity, 1989:1, 181-241.

Swanson, N.R. and D. van Dijk (2006), "Are statistical reporting agencies getting it right? Data rationality and business cycle asymmetry", Journal of Business & Economic Statistics, 24, 24-42.

Tosetto, E. (2008), Revisions of Quarterly Output Gap Estimates for 15 OECD Member Countries, OECD, Statistics Directorate, 26 September 2008.

Trimbur, T.M. (2009), Improving Real-Time Estimates of the Output Gap, Finance and Economics Discussion Series, Washington, D.C.: Federal Reserve Board, 2009-32.

Van Norden, S. (2002), Filtering for Current Analysis, Bank of Canada Working Paper No. 2002-28.

Tables

Table 1: Data availability

	Output gap (vintages)	Capacity utilisation (reference period)
Australia	1995:Jun–2009:Dec	1996q1-2009q4
Austria	1995:Jun–2009:Dec	1996q1-2009q4
Belgium	1995:Jun–2009:Dec	1980q1-2009q4
Czech Republic	2005:Dec–2009:Dec	1993q2-2009q4
Denmark	1995:Jun–2009:Dec	1987q1-2009q4
Finland	1995:Jun–2009:Dec	1993q1-2009q4
France	1995:Jun–2009:Dec	1985q1-2009q4
Germany	1995:Jun–2009:Dec	1985q1-2009q4
Hungary	2005:Dec–2009:Dec	1996q1-2009q4
Ireland	1995:Jun–2009:Dec	1985q1-2008q2
Italy	1995:Jun–2009:Dec	1970q1-2009q4
Japan	1995:Jun–2009:Dec	1978q1-2009q4
Luxemburg	2005:Dec–2009:Dec	1985q1-2009q4
Netherlands	1995:Jun–2009:Dec	1985q1-2009q4
New Zealand	1997:Jun–2009:Dec	1970q1-2009q4
Norway	1995:Jun–2009:Dec	1987q1-2009q4
Poland	2006:Dec–2009:Dec	1992q2-2009q4
Portugal	1995:Jun–2009:Dec	1987q1-2009q4
Spain	1995:Jun–2009:Dec	1987q2-2009q4
Sweden	1995:Jun–2009:Dec	1996q1-2009q4
Switzerland	1995:Jun–2009:Dec	1970q1-2009q4
United Kingdom	1995:Jun–2009:Dec	1985q1-2009q4
No. countries	22	22

Notes: The output gap information refers to publication dates; in general, the series included in these vintages start in 1970. The output gap data stem from the OECD Economic Outlook (various issues) as published on "Source OECD", http://www.sourceoecd.org/. The capacity utilisation information refers to the reference period. The main source is the harmonised business tendency surveys as published by the European Commission. Additional information is gathered from the OECD Main Economic Indicators, the National Bank of Belgium, METI in Japan, NZIER in New Zealand and the National Bank of Australia; see footnote 24 for more details.

Table 2: Descriptive statistics of the data vintages

	Maximum panel (22 countries, 1995-2009)					Strictly balanced panel (17 countries, 1996-2005)				
	Obs	Mean	St.D.	Min.	Max.	Obs	Mean	St.D.	Min.	Max.
Capacity utilisation (in % of full capacity)										
degree (in %)	353	81.51	4.40	64.54	92.30	170	81.43	2.97	74.43	87.53
Output gap (in % of potential GDP)										
Release 1	287	-0.93	1.98	-8.79	5.50	170	-0.79	1.58	-4.86	5.50
Release 2	283	-0.55	1.65	-5.73	5.68	170	-0.64	1.58	-4.27	5.68
Release 3	287	-0.40	1.75	-5.50	6.39	170	-0.53	1.64	-4.31	6.39
Release 4	283	-0.46	1.90	-7.31	6.41	170	-0.46	1.62	-4.06	6.41
Release 5	287	-0.38	1.97	-7.32	7.66	170	-0.38	1.65	-4.53	7.66
Release 6	283	-0.51	1.90	-9.54	6.77	170	-0.28	1.59	-3.16	6.77
Release 7	287	-0.48	1.96	-9.54	6.84	170	-0.24	1.64	-5.11	6.84
Release 8	283	-0.52	2.02	-9.66	6.83	170	-0.13	1.67	-4.17	6.83

Table 3: Descriptive statistics on the cumulate revisions of OECD output gap estimates

	Obs.	Mean	Sign.	St.Dev.	Min.	Max.	Skewness	Kurtosis	Jarque-Bera	Sign.
Maximum panel										
Revision 1	265	0.19	0.00	0.71	-2.90	3.06	0.09	4.44	218.09	0.00
Cumulative Revision 2	265	0.37	0.00	0.94	-2.46	3.98	0.33	1.68	36.10	0.00
Cumulative Revision 3	243	0.53	0.00	1.18	-2.51	6.83	1.27	3.97	225.36	0.00
Cumulative Revision 4	243	0.64	0.00	1.29	-3.55	6.86	0.76	2.57	90.20	0.00
Cumulative Revision 5	221	0.64	0.00	1.24	-3.99	6.14	0.49	2.38	61.01	0.00
Cumulative Revision 6	221	0.68	0.00	1.27	-3.71	5.83	0.29	1.26	17.70	0.00
Cumulative Revision 7	199	0.65	0.00	1.20	-3.95	3.90	-0.11	0.66	4.03	0.13
Strictly balanced panel										
Revision 1	170	0.15	0.00	0.63	-2.42	3.06	1.12	5.13	222.31	0.00
Cumulative Revision 2	170	0.26	0.00	0.86	-2.43	3.77	0.28	1.91	28.06	0.00
Cumulative Revision 3	170	0.33	0.00	1.01	-2.51	4.61	0.74	2.39	56.18	0.00
Cumulative Revision 4	170	0.41	0.00	1.12	-3.55	3.81	-0.02	0.80	4.58	0.10
Cumulative Revision 5	170	0.52	0.00	1.14	-3.99	4.28	0.02	1.53	16.58	0.00
Cumulative Revision 6	170	0.56	0.00	1.21	-3.71	4.01	-0.01	0.88	5.50	0.06
Cumulative Revision 7	170	0.66	0.00	1.24	-3.95	3.90	-0.15	0.59	3.11	0.21

Notes: the first column labelled "Sign." reports the p-value of the test that the mean of the series equals zero. The last column – also labelled "Sign." – is the p-value associated to the Jarque-Bera test for normality of the series.

Table 4: Regression results with increasing revision horizons

Dependent variable:	(1) R_2-R_1	(2) R_3-R_1	(3) R_4-R_1	(4) R_5-R_1	(5) R_6-R_1	(6) R_7-R_1	(7) R_8-R_1
	Maximum panel						
First release (y_{R1})	-0.26	-0.34	-0.49	-0.54	-0.51	-0.45	-0.44
	(-5.82)	(-7.62)	(-9.13)	(-7.73)	(-7.18)	(-5.81)	(-5.93)
Capacity utilisation rate	0.10	0.11	0.17	0.17	0.18	0.11	0.13
	(2.99)	(3.08)	(3.05)	(2.58)	(2.92)	(1.60)	(1.98)
Adjusted R^2	0.25	0.31	0.48	0.50	0.53	0.50	0.46
Number of observations	262	262	240	240	218	218	196
Number of countries	22	22	22	22	22	22	21
Number of periods	14	14	13	13	12	12	11
p-value F-test analysis of variance for country effects	0.07	0.05	0.05	0.01	0.00	0.00	0.00
p-value F-test analysis of variance for time effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-value F-test analysis of variance for time and country effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Strictly balanced panel						
First release (y_{R1})	-0.22	-0.35	-0.48	-0.55	-0.59	-0.54	-0.47
	(-3.74)	(-6.13)	(-8.00)	(-6.69)	(-7.35)	(-6.25)	(-5.63)
Capacity utilisation rate	0.06	0.13	0.17	0.19	0.23	0.16	0.16
	(1.53)	(2.50)	(2.44)	(2.66)	(3.29)	(1.99)	(2.19)
Adjusted R^2	0.19	0.26	0.32	0.37	0.47	0.45	0.49
Number of observations	170	170	170	170	170	170	170
Number of countries	17	17	17	17	17	17	17
Number of periods	10	10	10	10	10	10	10
p-value F-test analysis of variance for country effects	0.47	0.96	0.53	0.43	0.04	0.01	0.00
p-value F-test analysis of variance for time effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-value F-test analysis of variance for time and country effects	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Newey-West standard errors correcting for heteroskedasticity and autocorrelation up to order *x*-2 (where *x* equals the release number) are reported. Country and year dummies are included in all regressions.

Table 5: Regression results using the 7th cumulative revision

Dependent variable: cumulative revision 7 ($\Delta_{R8\text{-}R1}y$)	(1)	(2)	(3)	(4)	(5)
First release ($y_{R\,1}$)	-0.39	-0.47	-0.49	-0.42	-0.48
	(-6.09)	(-5.63)	(-6.00)	(-5.98)	(-5.91)
Capacity utilisation rate		0.16	0.18		0.12
		(2.19)	(2.57)		(1.90)
Capacity utilisation rate, lagged one period				0.17	0.12
				(2.52)	(1.92)
Adjusted R^2	0.47	0.49	0.49	0.50	0.50
Number of observations	170	170	167	167	167
Number of countries	17	17	17	17	17
Number of periods	10	10	10	10	10
p-value F-test analysis of variance for country effects	0.00	0.00	0.00	0.00	0.00
p-value F-test analysis of variance for time effects	0.00	0.00	0.00	0.00	0.00
p-value F-test analysis of variance for time and country effects	0.00	0.00	0.00	0.00	0.00

Notes: Newey-West standard errors correcting for heteroskedasticity and autocorrelation up to order 6 are reported. Country and year dummies are included in all regressions.

Figures

Figure 1: OECD output gap release and revision sequence

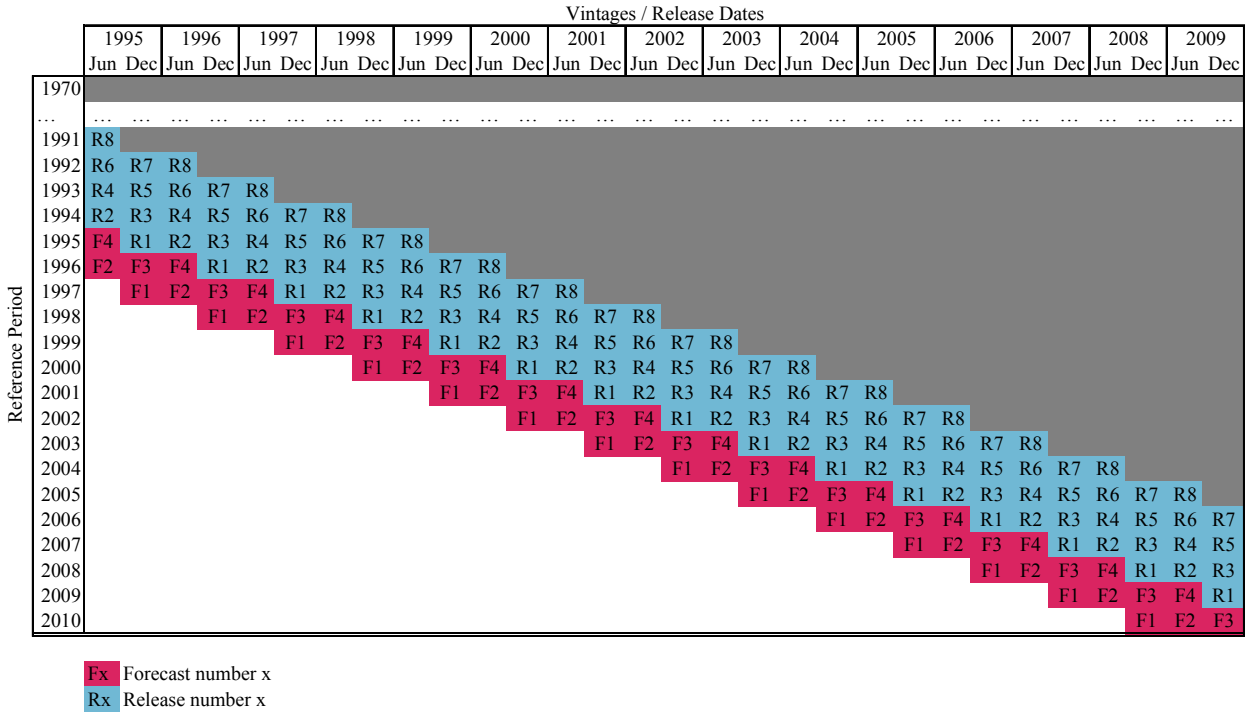
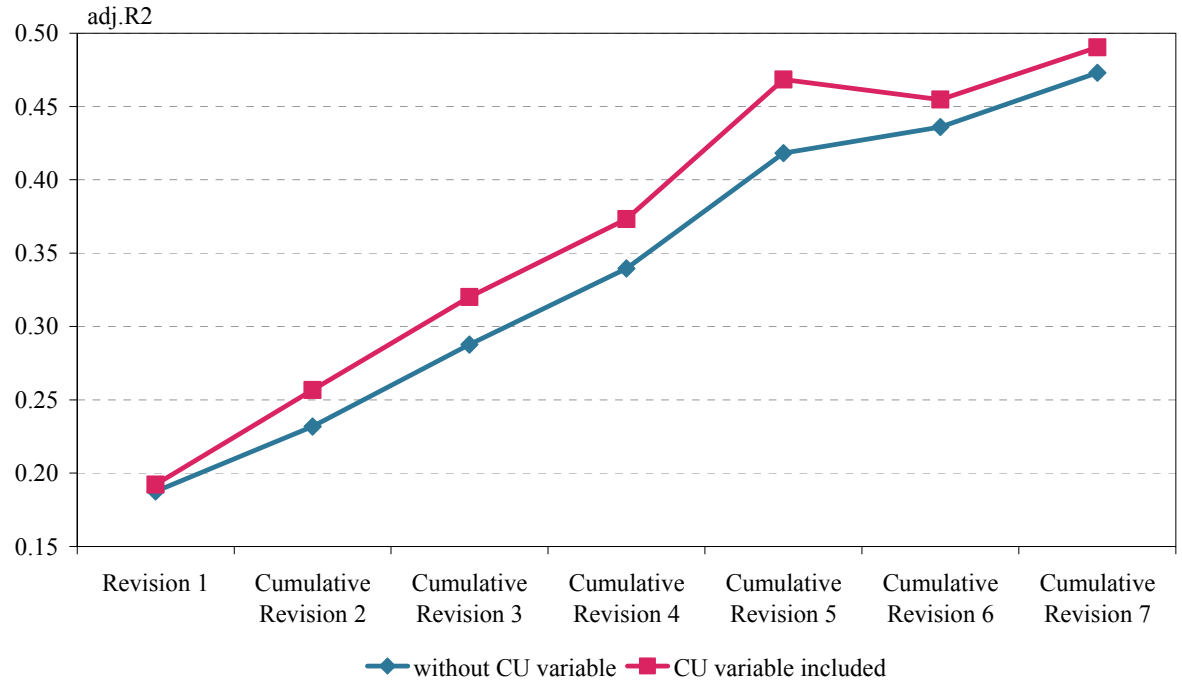
Figure 2: Adjusted R^2 for Equation (3) using annual data