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By Atanas Hristov, Rafal Raciborski and Valerie Vandermeulen

Summary

This economic brief provides a self-contained guide on the new Plausibility Tool, being a part of the *constrained discretion* approach to improving the Production Function methodology for calculating potential output and output gaps. It explains the macroeconomic model and its rationale, reports the results obtained with the tool during the ECFIN 2016 Autumn Forecast and provides their economic interpretation.

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Introduction

The concept of the output gap is central for assessing the cyclical position of the economy and in turn has important implications on the conclusions in the fiscal surveillance process emanating from the Stability and Growth Pact. However, until now, a degree of uncertainty surrounding the estimate of the output gap remains within the commonly-agreed *production function* methodology (PF). There are several types of uncertainty one could be concerned with: including, uncertainty about parameters of the models within the PF procedure (i.e., Phillips curve estimation, TFP estimation); uncertainty about the characteristics of noise processes in the respective models; uncertainty about the reference models themselves; and uncertainty about the data.

On the 25th of October, 2016, the EFC approved the use of the *plausibility tool* (PT) as part of the *constrained discretion* approach to improving the PF methodology. The PT is designed to help the Commission better deal with some forms of uncertainty mentioned above.[1] This economic brief provides a self-contained guide on the tool, with the emphasis given on the correct interpretation of the findings from the tool and laying down the intuition behind the differences between the PF methodology and the PT. The note first sketches the macro-economic model at the heart of the PT. Next, we show why the PT is the right step towards better dealing with some forms of uncertainty mentioned above. Then, it describes the results of the application of the PT during the autumn 2016 forecast. Finally, on the basis of these results, we discuss the contributions of the different cyclical factors in explaining fluctuations in the output gaps.

Before proceeding further, we would like to emphasise that the goal of the PT is not to deliver an *alternative* to the output gaps obtained within the PF methodology. Instead, we view the PT as a mechanism to ensure that no large estimation error for a country is made by using the PF methodology. A PF estimate is said to be *plausible* if it falls within a certain bound around the PT estimate. In short, a plausible PF output gap is in line with what several indicators of the business cycle would suggest. When the PF and PT output gap estimations are statistically not equal, a deeper investigation into what economic mechanisms can explain the discrepancy between the two approaches is started, which might lead to the conclusion that one of the two estimates is implausible.

The empirical macroeconomic model behind the plausibility tool

The PT uses a simple, flexible, empirically-based macroeconomic model in order both to capture the degree of uncertainty surrounding any estimate of the output gap as well as to determine an output gap, based on several cyclical indicators, for each member state for year T (i.e. 2016 in the latest forecast round). The procedure is simple and straightforward and consists of the following steps:

a) regress the output gaps obtained within the PF methodology (OG_{it}) for each country i on a commonly-agreed set of $k = 1, \dots, K$ cyclical indicators (X_{kit}, where t = time). The indicators that are chosen should be widely believed to be correlated with the latent variable driving the cyclical fluctuations in economic activity (i.e. the business cycle). The baseline regression is given by
eq (1): $OG_{it} = a + \sum_k \beta_k X_{kit} + v_i + \mu_t + u_{it}$
- where, a is a common intercept in the regression,
- β_k are coefficients weighting jointly the correlations between the output gaps OG_{it} and the cyclical indicatorsX_{kit},
- v_i is an unknown intercept for each member state (country fixed effect),
- μ_t is a time effect capturing the world business cycle,
- u_{it} is the country specific error term for each period t;

b) produce in-sample forecasts $\widehat{OG}_{it}$ of the output gaps (called throughout the note the *PT projections*):
eq (2): $\widehat{OG}_{it} = \hat{a} + \sum_k \hat{\beta}_k X_{kit} + \hat{v}_i + \hat{\mu}_t$,
where a "hat" over a parameter or a variable denotes an estimate.

c) identify "counterintuitive" PF output gaps as those gaps that fall outside the confidence bounds, as defined below.

Equation (1) explores the relationship between an outcome variable (OG_{it}) and its predictors (cyclical indicatorsX_{kit}) within all 28 European Member State (MS). Each MS has its own individual characteristics that may influence the predictor variables (e.g., the political system of a particular country could have some effect on its GDP and in turn on the output gap over a very long period of time). An assumption is made that these characteristics are relatively constant over time and, hence, can be captured by country fixed effects v_i, the intercepts for each MS. Fixed effects remove the

effect of time-invariant characteristics so we can assess the net effect of the predictors on the outcome variable.

In addition, Equation 1 adds time effects, μ_t, to the model. The reason for this addition is the need to control for the sources of variation or special events that affect all countries in the sample, but may not be fully captured by the cyclical indicators. This is especially important since adding a full list of world cyclical indicators which may be influencing the European business cycle is infeasible. We simplify and assume that all EU economies follow the world business cycle without any lead or lag, making the time effect constant across countries.

In the baseline estimation for the period between 2003 and 2016—where the time period is determined by data availability of some of the cyclical indicators—we use the following variables (see Table 1). The outcome variable, $\mathrm{OG_{it}}$, is by definition the gap between actual & potential GDP as estimated in the PF approach, based on the Autumn final vintage.

Table 1: **Exogenous variables used in the PT**

Title	Source
Capacity Utilisation	Capacity utilisation in manufacturing industry (Eurostat)
Short term UR	Total unemployment rate (Eurostat, DG ECFIN)
	Long-Term Unemployment in % of Unemployment (Eurostat)
	stur = harmonised unemployment rate minus the long-term unemployment rate
Wage Inflation	Annual change of wages per employee (DG ECFIN)
Slack in the Economy[2]	Business Surveys (DG ECFIN), Construction Confidence Indicator
	Business Surveys (DG ECFIN), Industrial Confidence Indicator
	Service Surveys (DG ECFIN), Services Confidence Indicator
	Gross value added for each sector (DG ECFIN)
Growth in GDP (lagged)	Annual change in real GDP (DG ECFIN)

Source: As specified in the table

These variables are selected because there is a wide consensus that they are strongly and unambiguously correlated with the business cycle.

To determine the uncertainty surrounding any estimate of the output gap in any particular year *t* for country *i* (see point c) above), we use the root-mean-square error (*RMSE*) equation

eq (3): $$RMSE_i = \sqrt{\frac{1}{T_i}\sum_t\left(\mathrm{OG_{it}} - \widehat{\mathrm{OG}}_{\mathrm{it}}\right)^2}$$

where T_i denotes the number of yearly observations for country *i*. The RMSE serves to aggregate the magnitude of the errors in the in-sample predictions over the whole sample into a single measure of predictive power. *RMSE* is one of the most commonly used measures of predictive accuracy. Let Q^m define the *m*th quantile of the normal distribution. Then, the confidence bounds are defined as:

$$Bound_{it}^{low} = \widehat{\mathrm{OG}}_{\mathrm{it}} - Q^m\, RMSE_i$$

$$Bound_{it}^{high} = \widehat{\mathrm{OG}}_{\mathrm{it}} + Q^m\, RMSE_i$$

We use two different RMSE criterions, based on different quantiles Q^m:

i) RMSE68 for $m = 68$;

ii) RMSE90 for $m = 90$.

In the end we define the plausibility check based on one of these 2 criterions as akin to *identification of outliers.* For example, for *m=68* quantile, the endogenous variable (in this case output gap) is expected to fall within the bounds in 68 out of 100 cases. (For *m=90* it is 90 out of 100 cases.) This last step thus checks whether the variables in the PF information set that make up the PF output gap estimation can be explained by the cyclical indicators considered in the PT. If the output gap falls outside the bounds, it may be then viewed as an outlier and is hence flagged as *potentially* "*counterintuitive*".

It should be noted, however, that the lower the quantile used, the higher probability of a "false positive". For example, the probability that a correctly estimated output gap is nonetheless flagged by the RMSE68 criterion is 1-.68=.32. Hence, this criterion should be expected to flag many false positive cases. The idea behind using such a broad criterion is to ensure that no "true positives" slip through the net. Following the Economic and Financial Committee (EFC) decision, countries flagged by the RMSE90 will be automatically considered as possibly counterintuitive and necessitating immediate further investigation. In contrast, due to the risk of false positives, output gaps that are only flagged by RMSE68 criterion will be referred to as *borderline cases*.

The rationale behind the PT

Uncertainty about the reference models, noise processes and parameter values

Notwithstanding the importance of the concept of the output gap, and the consequent desire for clarity, the measurement of potential growth is far from straightforward: since output gaps are unobservable, they need to be estimated. Fiscal surveillance requires collective rules, which is why the EU has the commonly agreed *production function* methodology. A large number of other possible approaches for estimating output gaps exist, with their own "pros" and "cons". It is even arguable that different methods may work best for different samples. Moreover, this model uncertainty (the uncertainty about whether a correct theoretical model has been used) is never possible to assess from within the model itself. Such an assessment can, however, be done from outside of the method (if another model, or a group of models is used for the assessment). This is one important piece of motivation behind the development of the Plausibility Tool.

Even conditional on the model being correctly chosen, there are several additional important sources of uncertainty. Conducting any form of estimation invariably requires making a certain number of arbitrary choices, first about the data and techniques of estimation, then the choice of specifications and finally at the level of parameters. Again, the validity of these choices, by construction, very often cannot be established using the method itself, hence, the usefulness of an additional verification tool.

The choice of the alternative method

Once the desirability for an additional verification instrument is established, the next step is, again, to choose the most suitable approach. As a general principle, the Commission has followed an approach of choosing as general a method as possible. With the PT we opted for a statistical model-free framework, which uses a comprehensive list of cyclical indicators in the estimation. The list of the variables is motivated by general stylised facts as to which indicators are most strongly correlated with the latent variable driving the cyclical fluctuations in economic activity. In this type of analysis, business cycles are characterised by the co-movement among hundreds of individual economic variables, taking into account possible leads and lags in timing.

The PT approach makes very few *a priori* assumptions about the model's shocks and parameters. For example, one can easily change or expand the cyclical indicators in the regression. This flexibility of the PT makes it a particularly suitable tool for *cross-validating the results* from the PF method. Furthermore, the tool can provide a measure of confidence about any estimate of the output gap for a particular set of cyclical indicators.

Thus this approach provides both an estimate of a reference model and a description of the model uncertainty. This is how the PT can contribute to discussing the three types of uncertainty mentioned in the title of this subsection.

Discussion of the dependent variable used

The PT uses as the dependent variable the estimates of output gaps that are an outcome from the PF method. Given that some of the exogenous variables used in the PT estimation are closely related to those used in the PF method, a relevant question arises whether the results obtained from the PT are not subject to a sort of 'confirmation' bias.

This is a valid concern. It could only be fully overcome if we could actually observe the true output gap, which unfortunately is not (and will never be) possible. However, the measurement problem is more severe at the end of the sample, due to data and forecast revisions and the end-point bias of statistical filter-based methods, such as a Hodrick-Prescott filter. Therefore, regressing the output gap on cyclical indicators over the whole sample should be expected to attenuate the problem.[3] Some evidence for this is provided by the regression results in Table 2 which shows that when we regress the output gaps of ECFIN, the OECD and the IMF (for an identical set of countries and years) we obtain very similar regression results, despite significant differences between the estimates of the output gap produced by these institutions in the final period.[4] In fact, a closer look at the regression coefficients shows that the coefficients for any of the indicators are in statistical terms undistinguishable across the three regressions.

Table 2: **Regressions of EC, OECD and IMF output gaps on the cyclical indicators**

		EC	OECD	IMF
Capacity Utilization	coef value	0.208*	0.298	0.196
	st error	(0.100)	(0.244)	(0.219)
Short Term UR	coef value	-0.814***	-0.883*	-0.611
	st error	(0.133)	(0.471)	(0.369)
Wage Inflation	coef value	0.250***	0.344**	0.266**
	st error	(0.069)	(0.147)	(0.104)
Slack in the economy	coef value	-0.027**	-0.01	-0.009
	st error	(0.012)	(0.018)	(0.018)
Growth in GDP (lagged)	coef value	0.300***	0.331***	0.281**
	st error	(0.055)	(0.095)	(0.099)
R2		0.917	0.815	0.798
N		201	201	201

Note: *** denotes 1% significance, ** 5% significance and * 10% significance.

Source: DG ECFIN analysis

Results of the PT, Autumn 2016 forecast

Table 3 below shows the results of the plausibility check for the output gaps in 2016. The left panel, which highlights countries for which the RMSE90 criterion was violated (which defines the clear-cut cases), flagged 3 output gaps in 2016, *Austria*, *Finland* and the *UK*, as being counterintuitively small. It also flagged 2 countries as having an output gap which was not positive enough (*Croatia and the Czech Republic*). There is a further discrepancy between the PT and PF procedures according to the RMSE68 criterion for *Austria*, *Finland*, *Italy*, *Luxemburg*, *Latvia*, *Slovenia and the UK*. For these countries the PT procedure suggests that the PF output gaps are not negative enough. For *Estonia*, *Greece and Portugal* the PT procedure suggests an output gap which should be less positive. In general we are more concerned about the countries flagged in red – those that have a PF output gap which might be too small.

The coefficients of the PT regression are shown in Table 4. [5]

Table 3: **The output gap based on the PF methodology and on the panel estimation, including the lower and upper bounds for the RMSE90 and RMSE68 criterions, 2016, based on the Autumn Final 2016 forecast**

PF Gap	PT Projec-tion	RMSE90			RMSE68		
			Bounds			Bounds	
		MS	Low	Up	MS	Low	Up
-0.7	-2.1	AT	-3.4	-0.9	AT	-2.9	-1.4
-0.4	-1.0	BE	-2.0	0.0	BE	-1.6	-0.4
-0.2	1.1	BG	-1.7	3.8	BG	-0.6	2.7
-0.8	-1.1	CY	-2.4	0.1	CY	-1.9	-0.4
0.1	1.3	CZ	0.4	2.2	CZ	0.8	1.9
0.0	0.0	DE	-1.0	0.9	DE	-0.6	0.6
-2.6	-1.8	DK	-3.1	-0.5	DK	-2.6	-1.0
-0.1	1.0	EE	-0.8	2.8	EE	-0.1	2.1
-10.5	-5.1	EL	-10.8	0.6	EL	-8.6	-1.7
-1.5	-1.2	ES	-3.1	0.6	ES	-2.3	-0.1
-1.8	-3.4	FI	-4.7	-2.1	FI	-4.2	-2.6
-1.4	-1.5	FR	-2.5	-0.4	FR	-2.1	-0.8
-0.9	0.6	HR	-0.7	1.8	HR	-0.2	1.3
0.7	1.0	HU	-0.3	2.4	HU	0.2	1.9
1.7		IE			IE		
-1.6	-2.1	IT	-2.8	-1.4	IT	-2.5	-1.7
0.9	0.3	LT	-1.9	2.5	LT	-1.0	1.7
-1.4	-3.4	LU	-6.1	-0.8	LU	-5.1	-1.8
1.4	-0.3	LV	-2.5	1.9	LV	-1.6	1.1
0.9	1.3	MT	0.2	2.5	MT	0.7	2.0
-0.8	-1.5	NL	-2.8	-0.3	NL	-2.3	-0.8
-0.1	-0.3	PL	-2.3	1.7	PL	-1.5	0.9
-0.8	0.1	PT	-1.2	1.4	PT	-0.7	0.9
0.3	-0.7	RO	-3.2	1.9	RO	-2.2	0.9
0.5	0.0	SE	-1.2	1.2	SE	-0.7	0.7
-0.3	-1.5	SI	-3.2	0.2	SI	-2.5	-0.5
-0.4	0.3	SK	-1.7	2.2	SK	-0.9	1.5
0.7	-0.7	UK	-1.9	0.6	UK	-1.4	0.1

Source: European Commission Autumn 2016 forecast

Note: PF gap: output gap calculated using the Autumn 2016 Final forecast, PT projection: output gap based on the panel estimation, lower bound and upper bound: limits within which we expect the output gap to be located according to the criterion used (RMSE68 or RSME90).

Note: Countries are red if the PT projection is lower (in most cases a more negative gap) than the PF method. Countries are yellow if the PT projection is higher (more positive, or less negative) than what was calculated using the PF method.

Note: IE is missing because of lack of data in the panel analysis.

Table 4: **PT estimation – 2016 Autumn Final**

	Coefficient	P-value
Capacity Utilisation	0.13	0.001
Short term UR	-0.79	0.000
Change in wage inflation	0.15	0.000
Slack in the economy	-0.03	0.002
Growth in GDP (lagged)	0.35	0.000
World Business Cycle	-2.66	0.000
N	353	
R^2	89%	

Source: DG ECFIN analysis

Contributions of the cyclical variables to capturing fluctuations in the output gap

It is important to provide some intuition behind the results provided in the previous section. To this end, we start by rewriting Equation 1:

eq (4) :

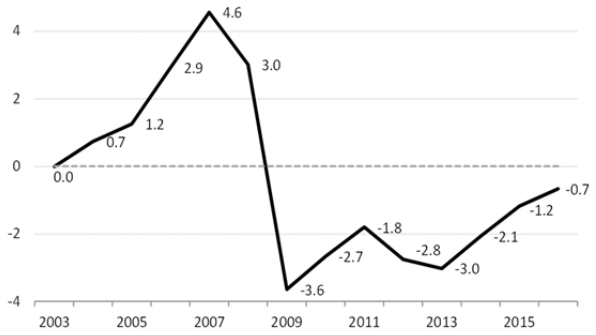
$$OG_{it} = (X_{it} - \overline{X_i})\,\beta + \mu_t + \overbrace{\overline{X_i}\beta + a + v_i}^{\varphi_i} + u_{it}.$$

It is apparent from Equation 4 that the output gap is a function of the deviation of the cyclical indicators from their long-run average,$(X_{it} - \overline{X_i})\,\beta$, as well as of changes in the external cyclical factors, μ_t.

Observe also that $\varphi_i = \overline{X_i}\beta + a + v_i$ captures the total country-specific effect. The effect is expected to be nil, if we were to have, say, over 10 complete business cycles of cross-country data; that is about 50 years if the average cycle lasts about 5 years. The idea is that in general any country has about half of the time a positive output gap and about half of the time a negative output gap. Since we have a short sample, only 14 years, and the sample coincides with the period after the onset of the Great Recession (see Figure 1), the estimates for φ_i may be different from 0.

Table 5 shows the contributing factors for the fluctuations in the member states output gaps in 2016. We report the lower and upper bounds around the projection. The criterion for the statistical significance is the 68 percentile. RMSE68 column reports the 68 percentile magnitude of the statistical error.

Figure 1: **Average of All Output Gaps across All Member States**



Source: DG ECFIN analysis

Note: The figure plots the average of the 28 output gaps for the European member states for each year in the period between 2003 and 2016, without weighting them according to the size of the member state economies.

Table 5 makes it clear that the recovery from the Great Recession is not complete, especially in the labour market. Look first at the fluctuations in the change in wage inflation from their sample average. There we observe that apart from Hungary and the Netherlands, changes in wage inflation in 2016 are still lower than over the average for the years 2003-2016, which puts downward pressure on the output gaps. The term $(X_{3it} - \overline{X_{3i}})\,\beta_3$ is negative. In addition, in several countries short-term unemployment in 2016 is still higher than the country-specific average of the unemployment in the period 2003-2016. This again points to unabated downward pressure preventing the output gap from closing. For these countries the term $(X_{2it} - \overline{X_{2i}})\,\beta_2$ is also negative.

The strongest downward pressure on the output gaps is exerted by the time effect,μ_{2016} the effect of the world cycle. Observe first that the fixed effect model treats all output gaps equally; that is, it does not weigh them according to the size of the economies. A look at Figure 1 shows that the average of all 28 member states PF output gaps in 2016 is -0.7 percentage points. Thus, for most member states the inclusion of the world business cycle with a coefficient of -2.7 percentage points leads to a rather negative PT output gap in 2016 (see Table 4). This finding of the PT model is congruent with the most recent forecasts of the IMF and the OECD. In their forecasts, they have pointed out that the growth rate in world GDP in recent years has fallen below expectations, also in 2016 in particular. This result reflects to a large extent the end of a period of rapid GDP acceleration compared to pre-crisis years in the

emerging market economies. The share of these economies has increased sizeably in respect to World GDP. The overall weakness in World economic activity has in turn been the primary restraint on trade growth and on the European business cycle in particular.

A closer look reveals that despite recent improvements, the majority of the cyclical indicators in the estimation for several countries flagged under the RMSE68 criterion (namely Austria, Finland, Luxemburg and Slovenia) have not recovered to their pre-crisis levels, in turn pushing the output gap into negative territory. In a similar vein, the PF output gap for Latvia is flagged mainly because the negative pressure coming from the change in wage inflation and GDP is big enough to counterweight the positive effects from the other indicators.

$$OG_{it} = (X_{it} - \overline{X_i})\,\beta + \overbrace{\overline{X_i}\beta + a}^{\varphi_i} + v_i + \mu_t$$

Table 5: **Results from the Plausibility Tool for 2016**

		Contributions Stemming from Deviation of the Indicators from Their Respective Country-Specific Average over the Period 2003-16					
		$(X_{1it}-\overline{X_{1i}})\,\beta_1$	$(X_{2it}-\overline{X_{2i}})\,\beta_2$	$(X_{3it}-\overline{X_{3i}})\,\beta_3$	$(X_{4it}-\overline{X_{4i}})\,\beta_4$	$(X_{5it}-\overline{X_{5i}})\,\beta_5$	φ_i
MS	RMSE_68	Capacity Utilisation	Short term UR	Wage inflation	Slack in economy	GDP Growth (lag)	
AT	0.8	-0.08	-0.28	-0.10	0.03	-0.15	1.09
BE	0.6	0.03	0.25	-0.20	0.02	0.02	1.52
BG	1.7	0.88	1.43	-0.35	0.09	0.05	1.61
CY	0.8	0.02	0.30	-0.11	0.02	0.05	1.24
CZ	0.6	0.06	1.29	-0.04	-0.03	0.66	2.03
DE	0.6	0.17	1.04	0.04	0.26	0.17	0.95
DK	0.8	-0.05	0.55	-0.11	-0.26	0.06	0.64
EE	1.1	0.14	0.65	-0.23	-0.10	-0.58	3.80
EL	3.5	-0.50	0.89	-0.13	-0.29	-0.08	-2.35
ES	1.1	0.24	1.27	-0.16	0.08	0.61	-0.60
FI	0.8	-0.41	-0.32	-0.17	-0.15	-0.29	0.63
FR	0.6	0.04	0.02	-0.25	-0.10	0.05	1.44
HR	0.8	0.42	1.85	-0.10	0.07	0.02	0.97
HU	0.8	0.20	1.33	0.00	0.29	0.40	1.46
IT	0.4	0.32	-0.15	-0.28	0.17	0.23	0.26
LT	1.3	0.68	1.75	-0.31	0.02	-0.73	1.59
LU	1.6	-0.23	-0.45	-0.31	-0.06	0.18	0.09
LV	1.3	0.45	1.23	-0.73	0.05	-0.28	1.67
MT	0.7	0.42	0.57	-0.02	0.52	1.11	1.39
NL	0.7	0.12	0.46	0.01	0.13	0.27	0.14
PL	1.2	0.42	1.22	-0.17	-0.36	0.08	1.21
PT	0.8	0.04	1.41	-0.04	0.17	0.46	0.74
RO	1.5	-0.12	0.15	-0.39	0.43	-0.03	1.96
SE	0.7	0.06	0.84	-0.01	0.22	0.65	0.92
SI	1.0	0.35	-0.01	-0.27	-0.19	0.12	1.17
SK	1.2	0.51	1.83	-0.41	-0.36	-0.08	1.45
UK	0.8	0.04	0.82	-0.06	0.21	0.21	0.79

Source: DG ECFIN analysis

Note: PF gap: output gap calculated using the Autumn 2016 Provisional forecast, PT projection: output gap based on the panel estimation, lower bound and upper bound (68 percentiles): limits within which we expect the output gap to be located according to the RMSE68 criterion. IE is missing because of lack of data in the panel analysis.

Conclusion

This note presented the Plausibility Tool, a new instrument for assessing the plausibility of the Production Function-based output gap estimates and provided the output of applying the Tool in the Autumn 2016 forecast. We argued that the PT procedure improves our understanding about the uncertainty surrounding any estimate of the output gap. Flagging the output gap in a particular country signals that further thought should be given onto why the PF estimate falls away by a wide margin from the PT estimate.

[1] The first version of the tool was developed by Wolfram Wilde from the German Ministry for Economics and Energy.

[2] The confidence indicator gives information whether demand is limiting the output, activity or business of companies today or in the next three months. If demand is insufficient, it is assumed that there is slack in the economy.

[3] In principle, estimation bias could further be reduced by excluding the last 2 years from the regression.

[4] For example, the OECD and the IMF allow for more judgment shaping the officially reported output gaps. Furthermore, the IMF does not have a uniform method across all desks, with some desks applying a production function approach, while other desks using a purely statistical filtering approach.

[5] Note that they are different than the values reported in Table 2, column "EC". The reason is that the sample from the estimation reported in Table 2 was adjusted (country-wise and time-wise) to align it with the IMF and OECD data samples. In particular, it is much smaller. It is, then, worth noting that, despite the very different estimation samples, the coefficients from the two estimations are in the same ballpark. This speaks for a relative stability of the PT method across countries.

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