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upB

An integrated approach for the estimation of the Italian output gap

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Roadmap

- Introduction
- The EU framework
- UPB and the OG
- New models for the OG
  - Introduction
  - Selection procedure
  - Models
  - Estimates in real time
  - Results
- Recent OG forecasts
- Conclusion

Definitions of the potential output

- Long-term growth: "The concept of potential output (PO) is generally understood to measure the medium-to-long-term level of sustainable real output in the economy. While measures of potential output growth abstract from short-term cyclical movements they can still fluctuate from year to year, reflecting supply conditions" (ECB, MB, Jan 2011).
- Balanced growth: "The level of output at which demand and supply in the aggregate economy are balanced so that, all else being equal, inflation tends to gravitate to its long-run expected value" (Mishkin, speech, 2007).
- Natural rate: "Potential output is the rate of output the economy would have if there were no nominal rigidities but all other (real) frictions and shocks remained unchanged" (Basu and Fernald,2009).

Model uncertainty

Potential output is unobservable, it can only be estimated with uncertainty.

- Modelling. The potential output may be measured using statistical methods (smoothing time series), or by means of theories (e.g. the production function) and structural models (cleaning the rigidities); large data-set were also used in the recent literature.
- Beyond the models. Large differences arise from the choices of the econometric specification and, eventually, also for a priori and initial conditions.

Real time uncertainty

Estimates of potential output are often revised, causing sub-optimality of the policies in real-time. The instability is due to various factors:

- Backward: data revisions may have an impact on the whole time series of potential and output gap.
- Current: the end of sample bias of statistical filters affects the real time measures for the actual values for potential output.
- Future: the end of sample bias may be mitigated considering also macroeconomic forecasts, but this comes at the cost of an additional source of uncertainty.

The EU framework: principles

1. It has to be a relatively simple and fully transparent methodology, where the key inputs and outputs are clearly delineated.
2. Equal treatment for all of the EU's Member States needs to be strictly assured.
3. Given that the estimates are used for budgetary surveillance purposes, it is important to produce unbiased estimates of the past and future evolution of potential growth by seeking to avoid both false optimism or unjustified pessimism.

The EU framework: the model

- Since 2002 the "official" estimates of the output gap (OG) for the EU countries are produced with a Commonly Agreed Methodology (CAM, approved by the ECOFIN); the methodology is continuously revised by the EPC-OGWG.
- The PO is based on the production function, where all the main components (except K) are decomposed between the trend and the cycle component.
- Each component (L, K and TFP) is estimated separately with different techniques: HP filter, bivariate Kalman filter, Bayesian Kalman filter.
- The model has been criticized because the potential growth is procyclical, unstable in real time and strongly affected by a priori and initial conditions.

Why fiscal councils care about PO and OG

- Long run. It is important to have a medium-term view of the economic growth, in order to analyse expenditure plans and the debt sustainability.
- Medium run. Output gap is relevant for the most relevant EU's fiscal rules (OMT convergence, debt and expenditure rule), other than for inflation projections.
- Short run. The output gap is a measure of the business cycle, which is relevant for the short term outlook.

Previous work at UPB: Fioramanti, Padrini and Pollastri (2015)

The research shows that the CAM model has many drawbacks, in particular in the NAWRU estimation, related to "minor" details of the model:

- Forecast horizon
- Choice of the software
- Variances' bound of the stochastic processes

They add to the major elements of difference (historical data revision, model choice, differences in forecast) potentially producing huge heterogeneities in potential output and output gap.
For this reason it is key to not only have a point estimate, but an interval/band around a central tendency, possibly obtained with tools taking into account different characteristics of an economy.

Previous work at UPB: Frale and De Nardis (2018)

- Frale and De Nardis estimate the output gap for Italy, over the period 1985- 2016, based on a set of models that uses UCM: the signal is extracted from output indicators (GDP, unemployment rate and capacity utilisation) and from a Phillips curve (similar to Jarocinski and Lenza (2016)).
- The selected models differ in their information sets and the specification of the trend.
- They analyse the performance of the different models by comparing them with estimates from international institutions and applying some measures of error.

Frale and De Nardis (2018): main results

- Alternative forms (trend,information set) of the model produce a broad range of values for the OG, confirming the considerable uncertainty characterising this variable.
- The uncertainty surrounding PO and OG is not eliminated by adopting a criterion for assessing the goodness of the various models: statistical criteria (maximum likelihood or stability of parameters) lead to the selection of different models from those that would be chosen using a more economic criterion, e.g capacity to forecast inflation.
- Indeterminacy depends on the considered period, reflecting particularly the influence exerted by the recent recession. Models that appeared optimal prior to the recent economic crisis seem to have lost their explanatory power in recent years.

New models for the output gap at UPB

- ✓ In a research project leaded by Tommaso Proietti, we have investigated several methods proposed in the literature: purely statistical, based on the economic theory and hybrid models.
- ✓ However none of them prevails: each one has its own advantages, in terms of statistical properties, stability of the estimates or economic interpretation.
- ✓ We ended up choosing an integrated approach that uses and summarizes all the results coming from different techniques and econometric specifications.
- ✓ This allows to construct a synthetic measure of PO and OG but also uncertainty bands that are particularly useful in the process of fiscal surveillance.

Selection procedure

We selected the five models accordingly to several criteria:

- Statistics: Likelihood, SE,residual diagnostic;
- Data: Revisions due to the data;
- Economics: Interpretation of the economic relations.

Selected Models

We selected the five models looking at several properties:

1. Bivariate model with inflation and output;
2. Bivariate model with inflation and output with shock in the cycle in 2009;
3. Trivariate model with inflation, output and unemployment;
4. Multivariate model in the framework of the production function;
5. Univariate statistical filter calibrated on the estimates of model 1.

Other attempts

We have done much more:

- Full replication of CAM method and sensitivity analysis to parameter restrictions (TFP and NAWRU) ;
- Different variables for TFP cycle (e.g. capacity utilization in industry, cig);
- Lower bound for TFP growth;
- Time varying parameters of the Phillips curve;
- Unemployment net of demographic trends;

Bivariate model with inflation and output

$$
\begin{aligned}
y_t &= \mu_t + \psi_t, & & & t = 1, \ldots, n, \\
\mu_t &= \mu_{t-1} + \beta_{t-1} + \eta_t, & & \texttt{trend: LLT} & \eta_t \sim \text{IID}N(0, \sigma_\eta^2), \\
\beta_t &= \beta_{t-1} + \zeta_t, & & & \zeta_t \sim \text{IID}N(0, \sigma_\zeta^2), \\
\psi_t &= \phi_1 \psi_{t-1} + \phi_2 \psi_{t-2} + \kappa_t, & & \texttt{cycle:AR(2)} & \kappa_t \sim \text{IID}N(0, \sigma_\kappa^2), \\
\pi_t &= \gamma_e \pi_t^e + \pi_t^* + \theta_0 \psi_t + \theta_1 \psi_{t-1} + \textstyle\sum_{k=1}^K \beta_k x_{kt} + \varepsilon_{\pi t}, & & & \varepsilon_{\pi t} \sim \text{IID } N(0, \sigma_{\varepsilon\pi}^2), \\
\pi_t^* &= \pi_{t-1}^* + \eta_{\pi t} & & \texttt{Phillips curve} & \eta_{\pi t} \sim \text{IID } N(0, \sigma_{\eta\pi}^2),
\end{aligned}
$$

We have investigated different specification for the trend, following Frale and De Nardis (2018).

Bivariate model with shock in 2009

The residuals of the bivariate model have a clear outlier in 2009, following the burst of the global financial crisis. To pick up the special feature of the business cycle in this occasion we allow the bivariate model to include a shock:

- in the level of the trend (μ_t)
- in the growth rate of the trend (β_t)
- in the cycle (ψ_t)

Results in terms of likelihood are very similar, but we recognize a better economic interpretation for the model with the shock in the cycle. Therefore we selected this model, by adding an intervention variable in the specification of the cycle such as: $\psi_t = \phi_1 \psi_{t-1} + \phi_2 \psi_{t-2} + \kappa_t + \lambda I(t = \tau)$, con $\tau = 2009$.

Trivariate model: inflation, output and unemployment

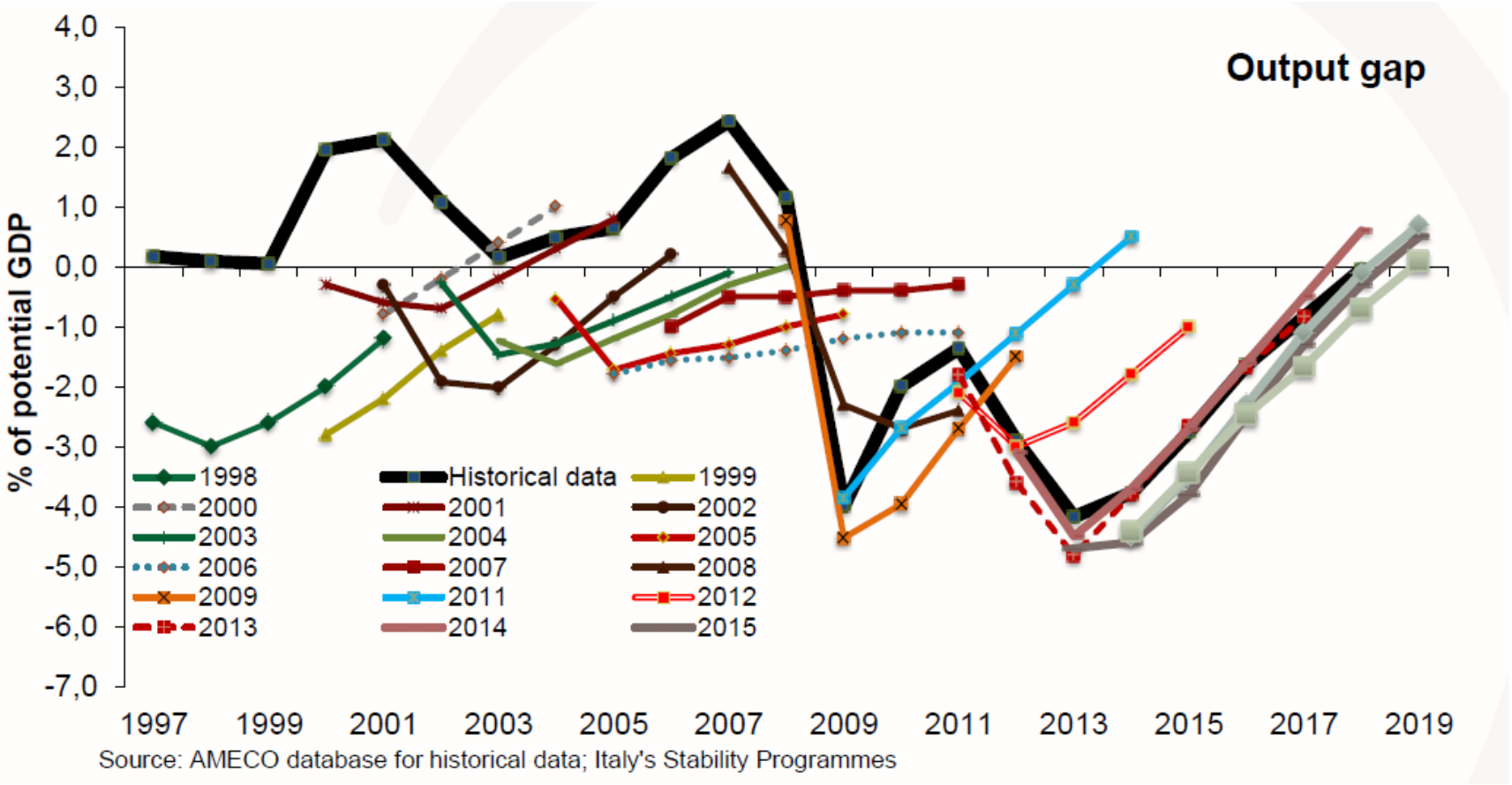
The bivariate model completely neglects the labour market. We thus extend it by adding the Okun(1962) law, that postulates a relation between output gap and unemployment gap. The trivariate model is obtained by adding an equation for Unemployment rate (U_t) to the basic structure of the bivariate model. We allow for a more general formulation than the strict proportionality:

$$
\begin{aligned}
U_t &= \mu_{ut} + \psi_{ut}, & t = 1, \ldots, n, \\
\mu_{ut} &= \mu_{u,t-1} + \beta_{u,t-1} + \eta_{ut}, & \eta_{ut} \sim \text{IID}N(0, \sigma^2_{\eta u}), \\
\beta_{ut} &= \beta_{u,t-1} + \zeta_{ut}, & \zeta_{ut} \sim \text{IID}N(0, \sigma^2_{\zeta u}), \\
\psi_{ut} &= \phi_u \psi_{u,t-1} + \delta_0 \psi_t + \delta_1 \psi_{t-1} + \kappa_{ut}, & \kappa_{ut} \sim \text{IID}N(0, \sigma^2_{\kappa u}),
\end{aligned}
$$

unemployment gap output gap

OG revisions with CAM

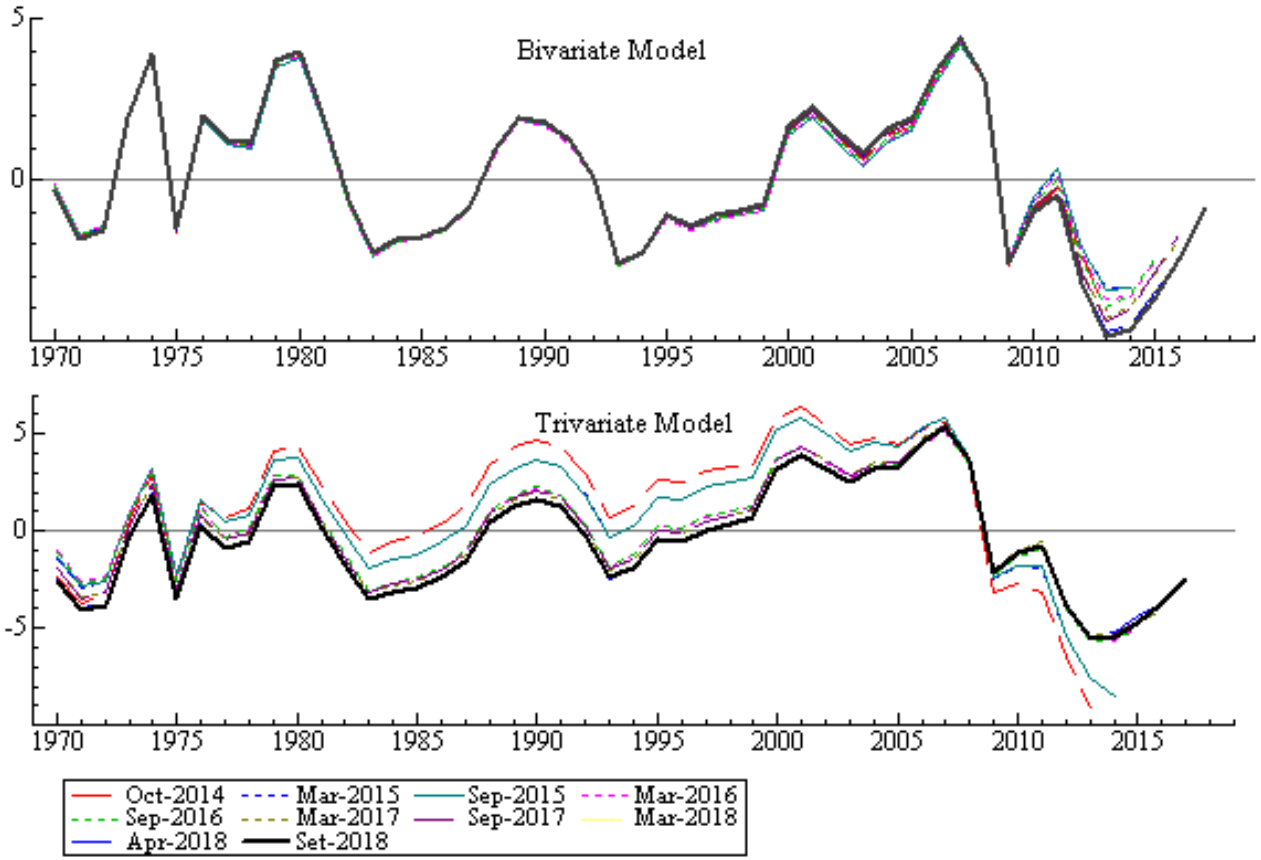
Estimates of OG with the EC model are generally revised (sometimes substantially) when new observations are added. This is not desirable in the framework of fiscal surveillance.



Source: AMECO database for historical data; Italy's Stability Programmes

Estimates in real time

We analyse the revisions of our models running a real time experiment.



Results show that the bivariate model is more stable than the trivariate (adding UR augment the volatility).

Multivariate integrated model

We propose also a multivariate model in the framework of the production function approach, where all components (labour, capital and TFP) are estimated simultaneously and efficiently (exploiting the cross correlation among variables), as proposed by Proietti, Musso and Westerman (2007) and ECB (2018). In this framework the trend and cycle of the output are obtained as combination of the analogues extracted from L, K and TFP:

$$y_t = f_t + \alpha l_t + (1-\alpha)k_t = \mu_t + \psi_t$$

$$\mu_t = \mu_{ft} + \alpha(\mu_{ht} + \mu_{at} + \mu_{et} + p_t) + (1-\alpha)k_t \quad \texttt{trend}$$

$$\psi_t = \psi_{ft} + \alpha(\psi_{ht} + \psi_{at} + \psi_{et}) \quad \texttt{cycle}$$

Thus the usual state space form is derived.

Multivariate integrated model

Given $Y_t = (f_t, a_t, h_t, e_t, c_t)'$, where f_t is the Solow residual, a_t the participation rate, h_t hours worked per capita, e_t the employment rate and c_t is the CUBS, and given $\mu_t = (\mu_{ft}, \mu_{ht}, \mu_{at}, \mu_{et})'$, $\psi_t = (\psi_{ft}, \psi_{ht}, \psi_{at}, \psi_{et})'$, $\psi_t = \gamma' \psi_t$, $\gamma = (1, \alpha, \alpha, \alpha)'$ we have:

$$
\begin{aligned}
Y_t &= \mu_t + \psi_t && t = 1, \ldots, n, \\
\mu_t &= \mu_{t-1} + \beta_{t-1} && \\
\beta_t &= \beta_{t-1} + \zeta_t && \zeta_t \sim \text{IID} N(0, \Sigma_\zeta) \\
\psi_t &= \phi_1 \psi_{t-1} + \phi_2 \psi_{t-2} + \kappa_t && \kappa_t \sim \text{IID} N(0, \Sigma_\kappa), \\
c_t &= \theta_c \psi_{ft} + \varepsilon_{ct} && \varepsilon_{ct} \sim \text{IID } N(0, \sigma^2_{\varepsilon c}), \\
\pi_t &= \gamma_e \pi^e_t + \pi^*_t + \theta_0 \psi_t + \theta_1 \psi_{t-1} + \textstyle\sum_{k=1}^{K} \beta_k x_{kt} + \varepsilon_{\pi t}, && \varepsilon_{\pi t} \sim \text{IID } N(0, \sigma^2_{\varepsilon \pi}), \\
\pi^*_t &= \pi^*_{t-1} + \eta_{\pi t} && \eta_{\pi t} \sim \text{IID } N(0, \sigma^2_{\eta \pi}),
\end{aligned}
$$

TFP cycle: CUBS

Σ_ζ is diagonal, whereas Σ_κ is full. The multivariate cycle has scalar coefficients that are the same of the OG. The CUBS indicator is a combination of survey data on capacity utilization, and business confidence, as done by EC.

Statistical filter

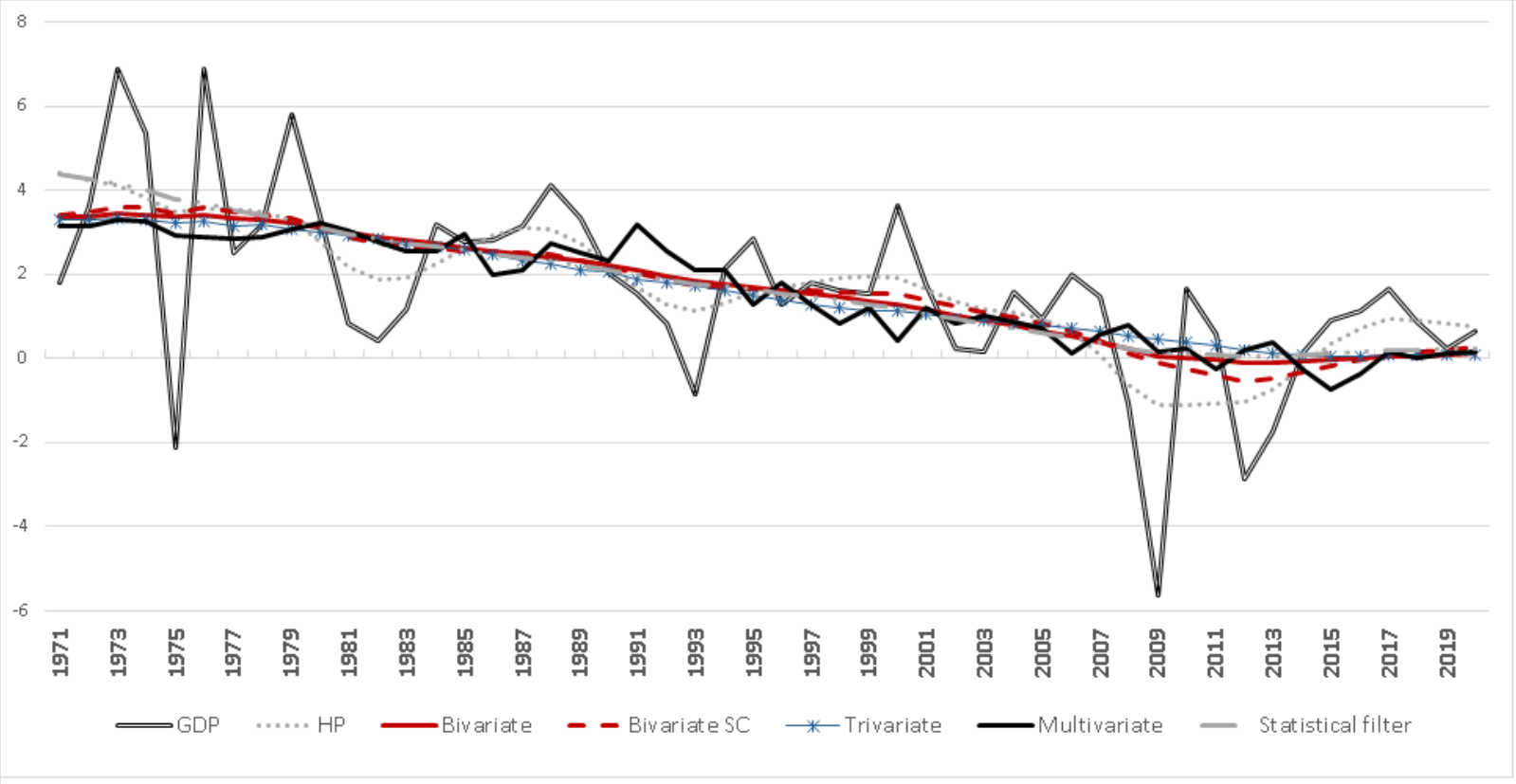
- Starting from the production function $y_t = f_t + \alpha l_t + (1-\alpha)k_t$ a simpler way to compute potential output is applying a univariate statistical filter to each component.
- The Hodrick and Prescott (1997) filter is the most used in this literature. HP is simple, but completely predefined and affected by the end of point bias.
- We use a specific filter, similar to HP, but set in order to mimic the cycle component of GDP, as derived from the bivariate model presented before (which appears to be quite stable in real time).
- This is easily accomplish by using a standard (LLT) model trend+cycle for GDP with the following restrictions:

$$\sigma_\eta^2 = 0, \sigma_\zeta^2 = 0.0168\sigma_\kappa^2, \rho = 0.56, \lambda_c = 0.04,$$

where ρ is the damping factor and λ_c the cycle frequency (remind: $\phi_2 = -\rho^2$; $\phi_1 = 2\rho cos\lambda_c$).

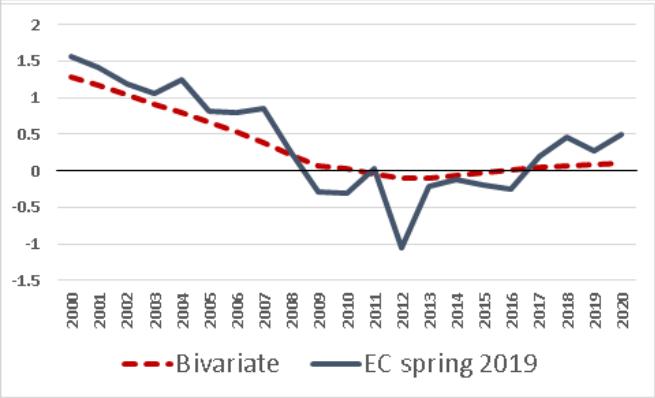
Results: Potential output (1)

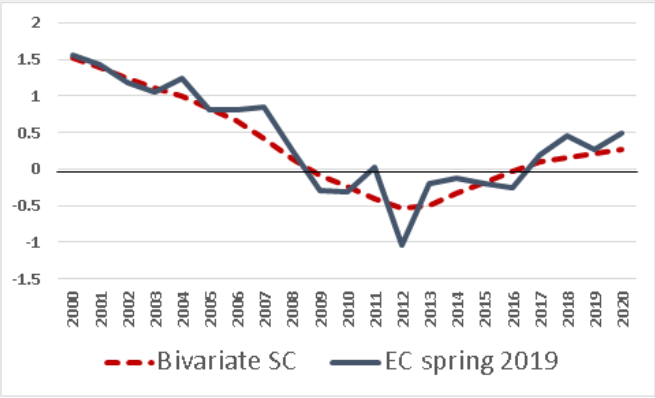
Figure: GDP and potential growth in the different models

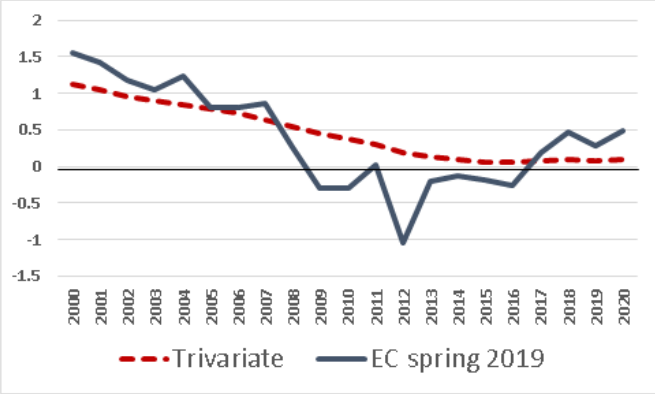


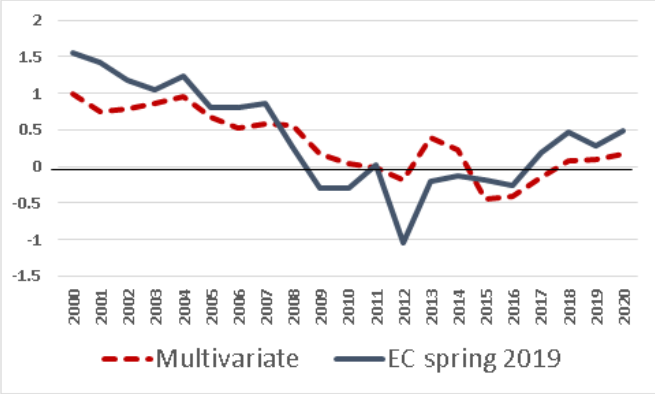
There is a clear downside trend in potential output in all models, which is coherent with weak GDP growth.

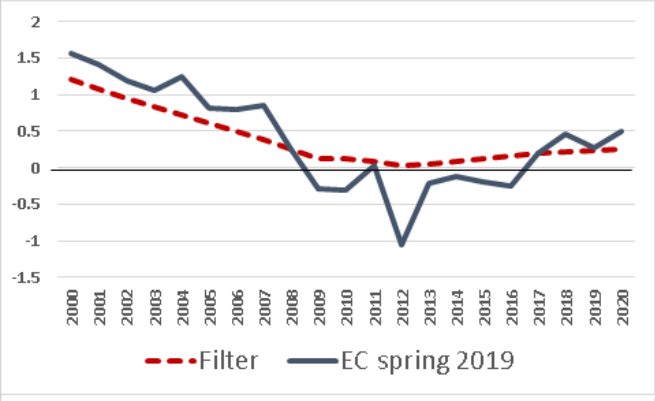
Potential output (2): UPB models and CAM (2019 estimates)

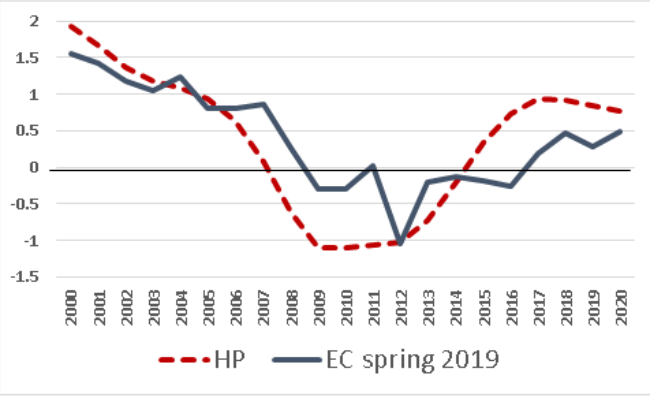










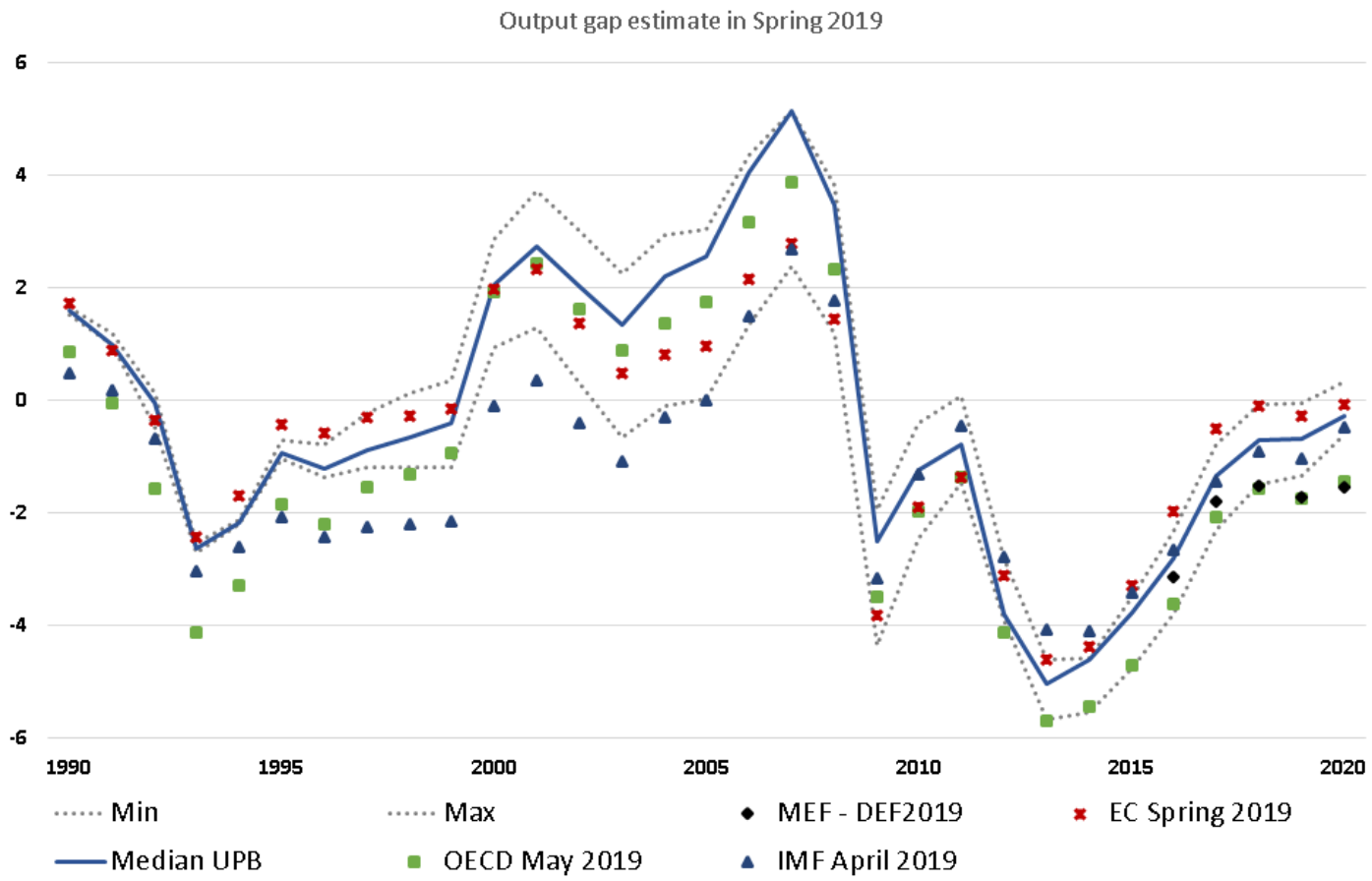


Results: Potential output (3)

- ✓ The bivariate model with the shock estimates a stronger reduction in potential output during the last big recession but it appears more volatile that the simple bivariate as it provides a stronger rebound in recent years.
- ✓ The Trivariate model produces a smoother potential: part of the downturn in the recession period is assigned to the unemployment gap. In current years a relevant part of the unemployment is still considered temporary and thus the output gap results smaller than the same computed by the bivariate model.
- ✓ Results from the multivariate model are the most volatile; after 2015 the potential growth is limited by the capacity utilization dynamics.
- ✓ The statistical filter produces intermediate results from the trivariate and bivariate models.
- ✓ PO of UPB models are less volatile than those of HP and CAM.

Results: OG forecasts (1)

- UPB uses the 5 models (along with CAM and HP) in order to evaluate the Government projections; the models are combined in order to derive a synthetic measure but also a plausibility band.
- The 5 models are integrated with the other tools used at UPB for the validation.



Results: OG forecasts (2)

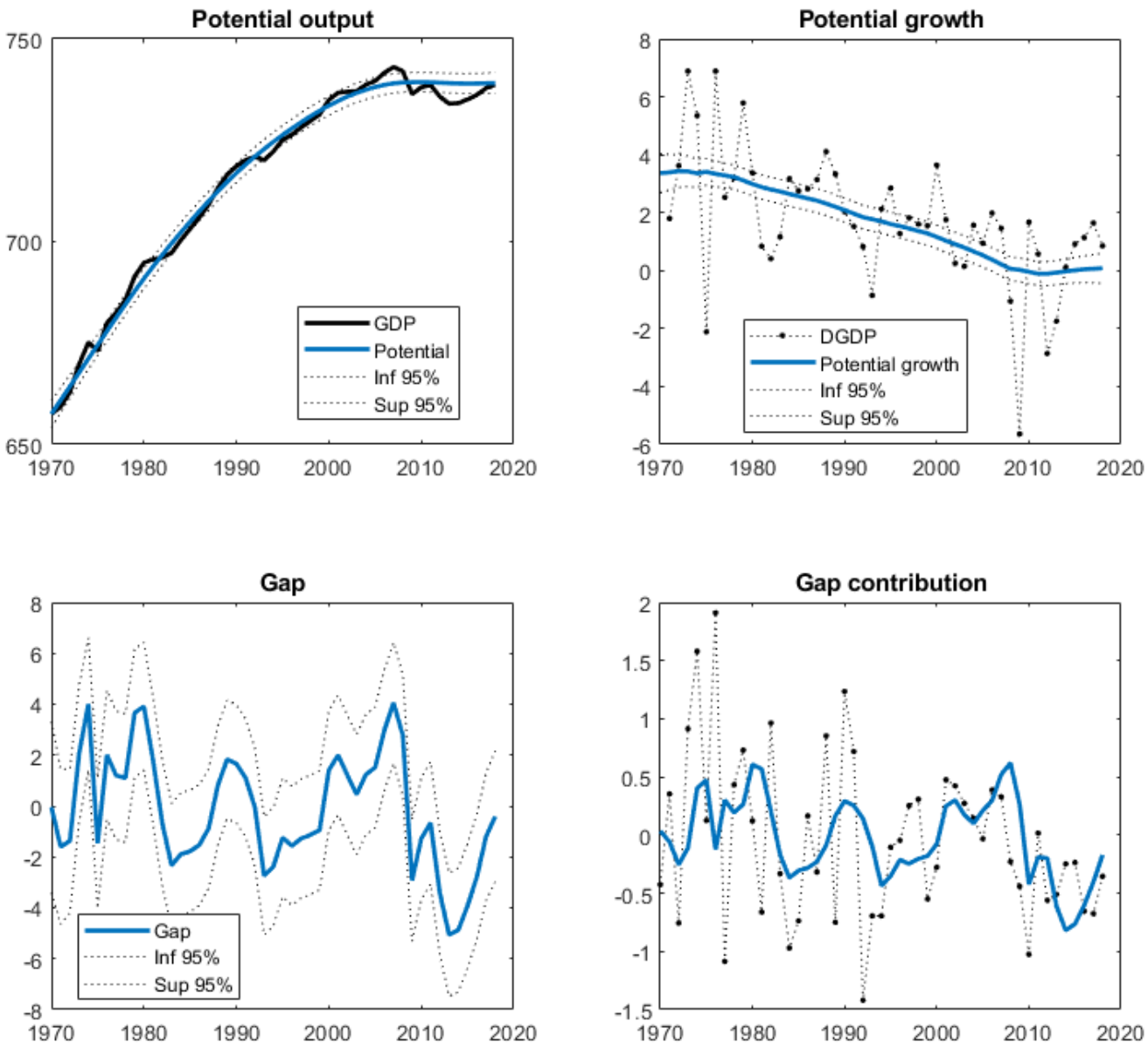
- ✓ We compare our OG estimates computed in Spring 2019 with those produced by the Government and EC. The macroeconomic framework is quite similar: GDP is foreseen to increase very modestly by all institutions, especially in 2019 (around 0,1 per cent).
- ✓ The median OG by UPB models is quite close to the measure provided by EC: turning points are almost coincident. Tough potential output estimated by UPB is less procyclical and the resulting OG more volatile.
- ✓ EC estimates lie almost always in the range between maximum and minimum of UPB models.
- ✓ Also Government estimates are inside the plausibility band, but only up to 2019, while afterwards they appear to be smaller (wider negative OG) than those produced by UPB.

Summary and conclusion

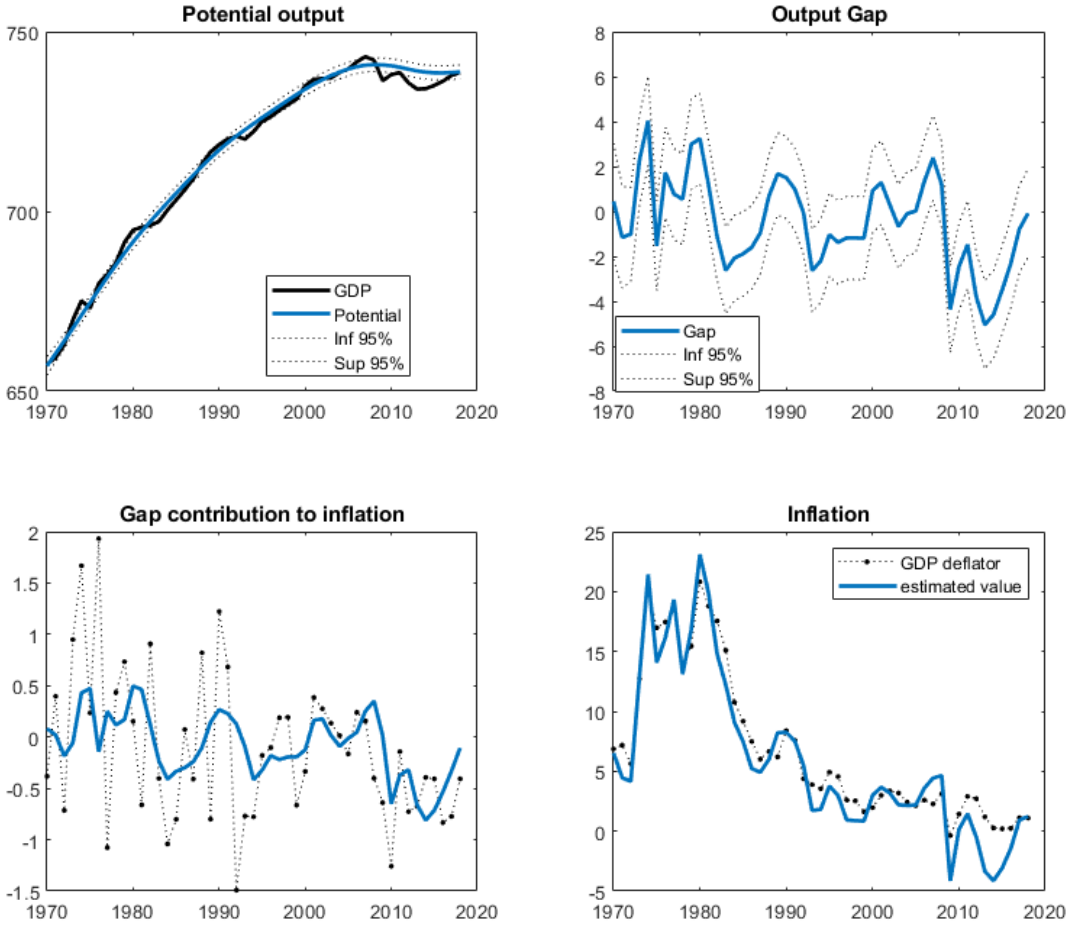
- ✓ We develop new models for the potential output and the output gap of the Italian economy, that encompass different economic and statistical approaches.
- ✓ The models are relatively robust to data revision in real time.
- ✓ We construct uncertainty measures based on the heterogeneity of the estimates across models.
- ✓ The median output gap of the new models is between the estimates of the EC and the MEF up to this year; more oriented toward the EC values in 2020.

Thank you for attention!

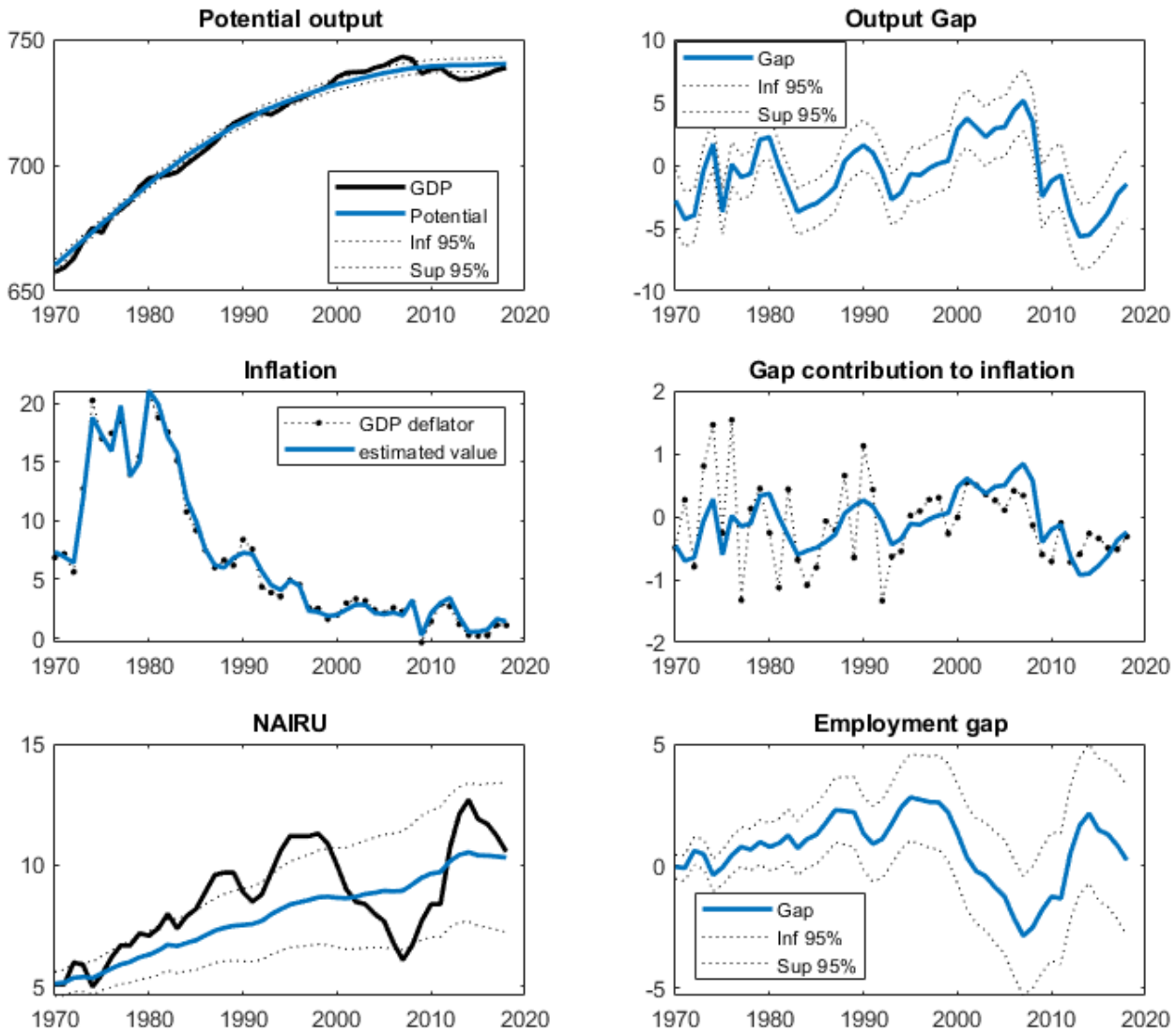
Bivariate Model



Bivariate Model with shock



Trivariate Model



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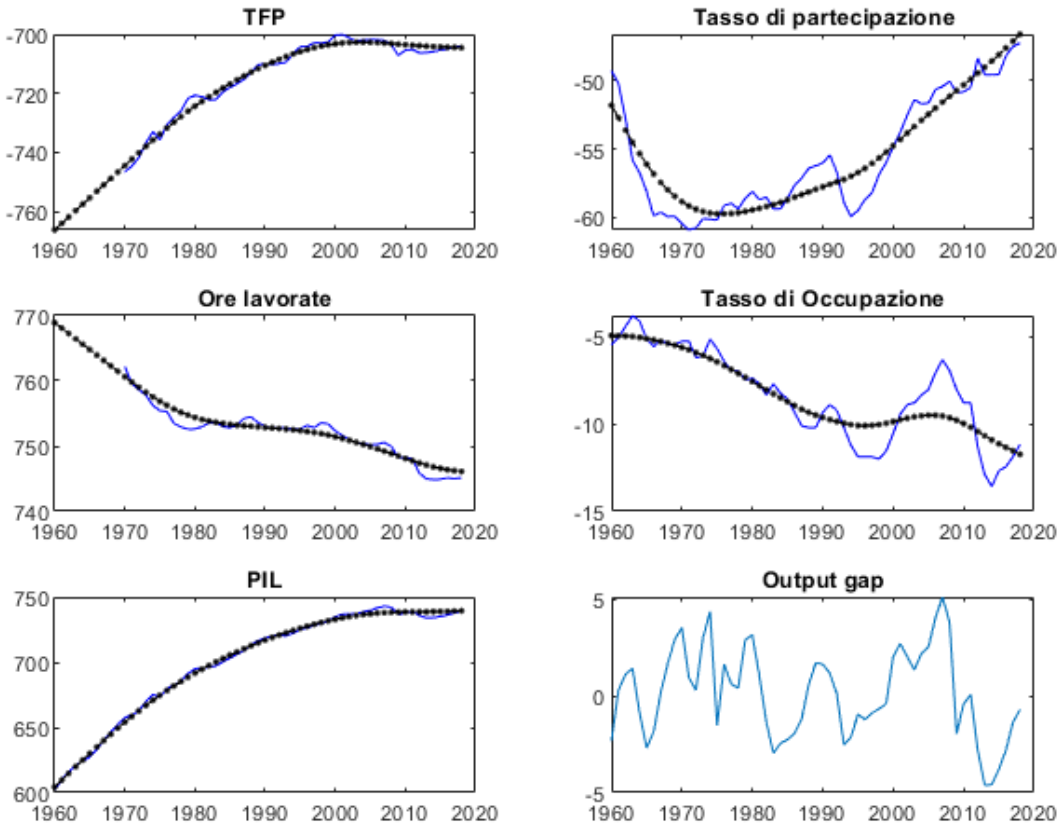
TFP
-700
-720
-740
-760
1960 1970 1980 1990 2000 2010 2020
Tasso di partecipazione
-50
-55
-60
1960 1970 1980 1990 2000 2010 2020
Ore lavorate
770
760
750
740
1960 1970 1980 1990 2000 2010 2020
Tasso di Occupazione
-5
-10
-15
1960 1970 1980 1990 2000 2010 2020
PIL
750
700
650
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Output gap
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-5
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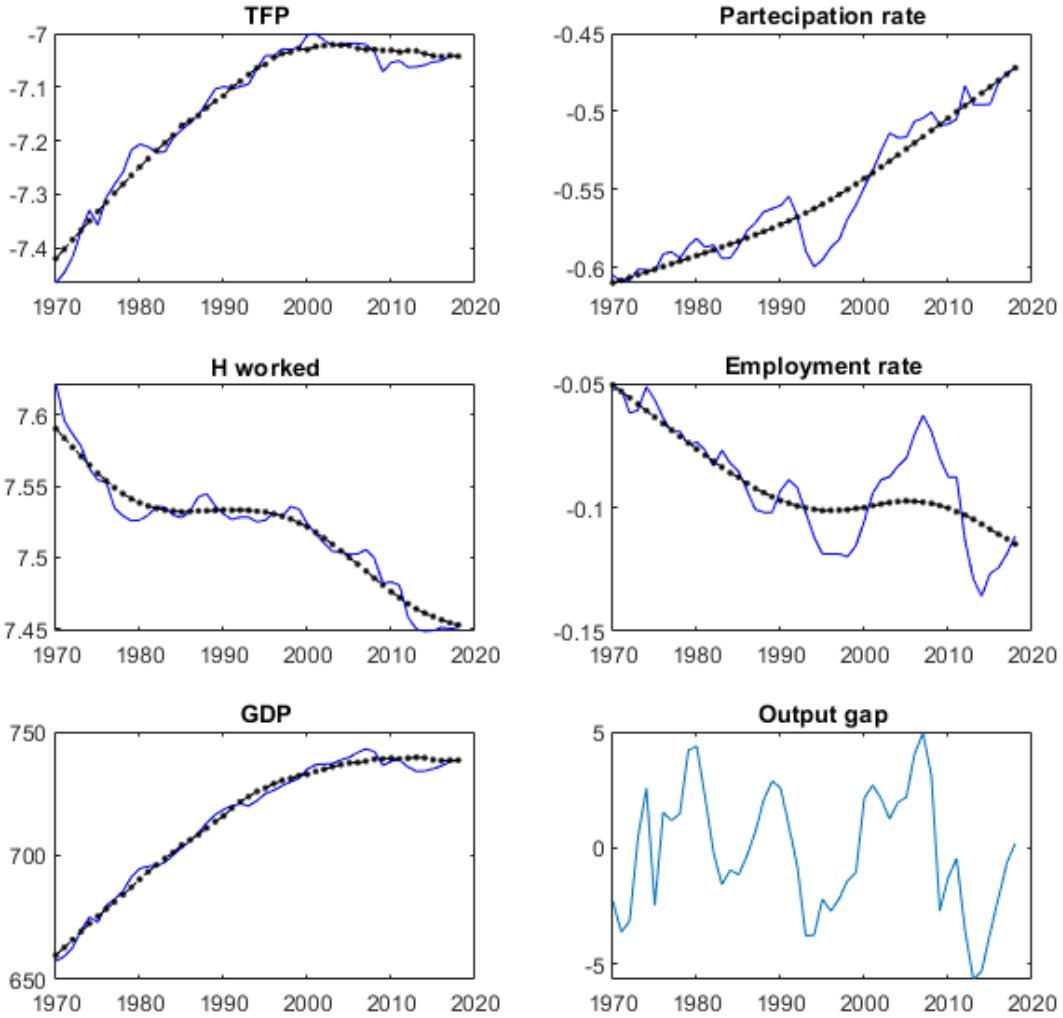
Multivariate Model



Multivariate Model Gaps