



## Center for Macroeconomic Analysis and Short-term Forecasting

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# «New normal», Output Gap and Multivariate Kalman Filter

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## **Research question: How «normal» is the «New Normal»?**

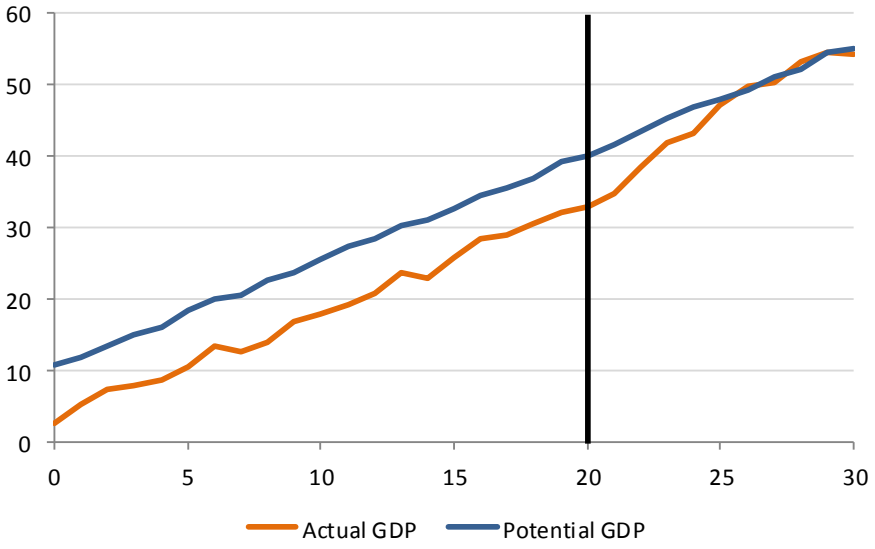
- World economy slowdown in 2011-2013 was foreseen by Bill Gross (PIMCO). He coined in the term «New Normal» in 2009 for a period of about 2010-2015. We have some data now to tell whether it is **structural** (as the term implies) or **cyclical** slowdown
- Demand-side measures only work for **cyclical** slowdowns, in case of **structural** slowdowns this policy only leads to overheating
- IMF estimates for 2014 US output gap as -3.5%, euro area output gap as -2.8%, output gap in Japan – only -1.6% potential GDP
- **Is the «New Normal» cyclical or structural?**

# Research question: How «normal» is the «New Normal»?

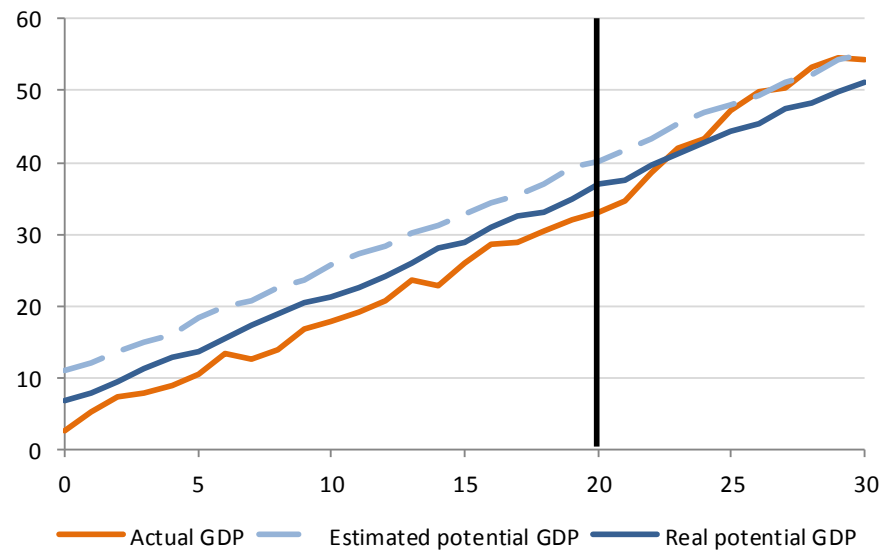
## Assumptions:

- ✓ the same growth rate of actual and potential GDP
- ✓ existence of negative output gap
- ✓ after 20<sup>th</sup> point demand-side measures are implemented for gap elimination

### Case 1: potential GDP estimate is correct



### Case 2: potential GDP estimate is biased



- In case 1: negative output gap is closed by demand-side measures
- In case 2: demand-side measures lead to overheating

- **Potential GDP** is *some* long-term GDP trend that differs from actual GDP for the output gap that is usually perceived to be the **cyclical** component of GDP growth

$$GDP \equiv GDP^{potential} + Output\ gap$$

- A barrage of methods and model specifications (most of them Kalman filter-based) to estimate potential GDP for the largest economies
- Data for GDP, labour force, inflation, labour and capital stock in US, euro area, China and Japan for 1985-2013
- What external restrictions to impose?
  - ✓ Okun's law
  - ✓ Phillips curve (or Lucas-Friedman AS)
  - ✓ Taylor rule
  - ✓ Equilibrium Current Account (Milesi-Ferretti)
- Testing for post-crisis structural break in estimated data

- **Methods to estimate potential GDP can be divided into three groups (Andrle, 2013; Gerlach, 2011; Johnson, 2013):**
  - ✓ *structural* – usually production function-based (Cobb, Douglas, 1928; Artus, 1977; De Masi, 1997)
  - ✓ *univariate nonstructural* – series smoothing, including filtering:
    - Hodrick, Prescott (1997)
    - Baxter, King (1999) aka Band-pass filter
    - Kalman (1960)
  - ✓ *multivariate nonstructural* – allow for structural restrictions in smoothing, but do not require production factors data (scarce and unreliable for developing economies)
    - Laxton, Tetlow (1992)
    - Kuttner (1994)

## How to estimate potential GDP: Formulas (1)

- **Production Function (PF)** is usually log Cobb-Douglas with constant returns to scale. Potential output is based on least-squares-calibration, actual capital stock series and smoothed (usually HP-filtered) labour stock series (or vice versa)

- **HP-filtering** is smoothing for actual series of output to this rule:

$$L = \sum_{t=1}^T y_t - \bar{y}_t^2 + \lambda \sum_{t=2}^{T-1} \Delta \bar{y}_{t+1} - \Delta \bar{y}_t^2,$$

- ✓  $y_t$  is actual output,  $\bar{y}_t$  is smoothed series (aka potential output),  $\lambda$  is smoothing degree, for yearly data  $\lambda = 100$

- **Band-pass (BP) filtering** is treating cyclical component (aka output gap) as a high-frequency component

- **Univariate Kalman filter (Unobservable Components (UC) Model** in a state-space model) is decomposing actual data into two series:

$$y_t = y_t^p + z_t,$$

$$y_t^p = y_{t-1}^p + \mu_{t-1},$$

$$\mu_t = \mu_{t-1} + \zeta_t,$$

$$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-2} + \gamma_t,$$

- ✓  $y_t^p$  is trend (potential output),  $z_t$  is a cyclical component (output gap),  $\zeta_t$  and  $\gamma_t$  are white noise

## How to estimate potential GDP: Formulas (2)

- **Multivariate Kalman filter (Multivariate UC Model** in a state space form) allows for structural restrictions in smoothing
- **Phillips curve for bivariate Kalman filter (GDP+CPI)**

$$cpi_t = \alpha_0 + \alpha_1 cpi_{t-1} + \alpha_2 z_t + \eta_t,$$

✓  $cpi_t$  is CPI,  $z_t$  is cyclical component of GDP (output gap),  $\eta_t$  is white noise

- **Okun's law for trivariate Kalman filter (GDP+CPI+UR)**

$$u_t = nairu_t + g_t,$$

$$nairu_t = nairu_{t-1} + \xi_t,$$

$$g_t = \alpha_1 g_{t-1} + \alpha_2 z_{t-1} + \alpha_2 z_{t-2} + \varepsilon_t,$$

✓  $u_t$  unemployment rate,  $nairu_t$  is NAIRU,  $g_t$  is cyclical component of unemployment,  $z_t$  is cyclical component of GDP (output gap),  $\xi_t$  and  $\varepsilon_t$  are white noise

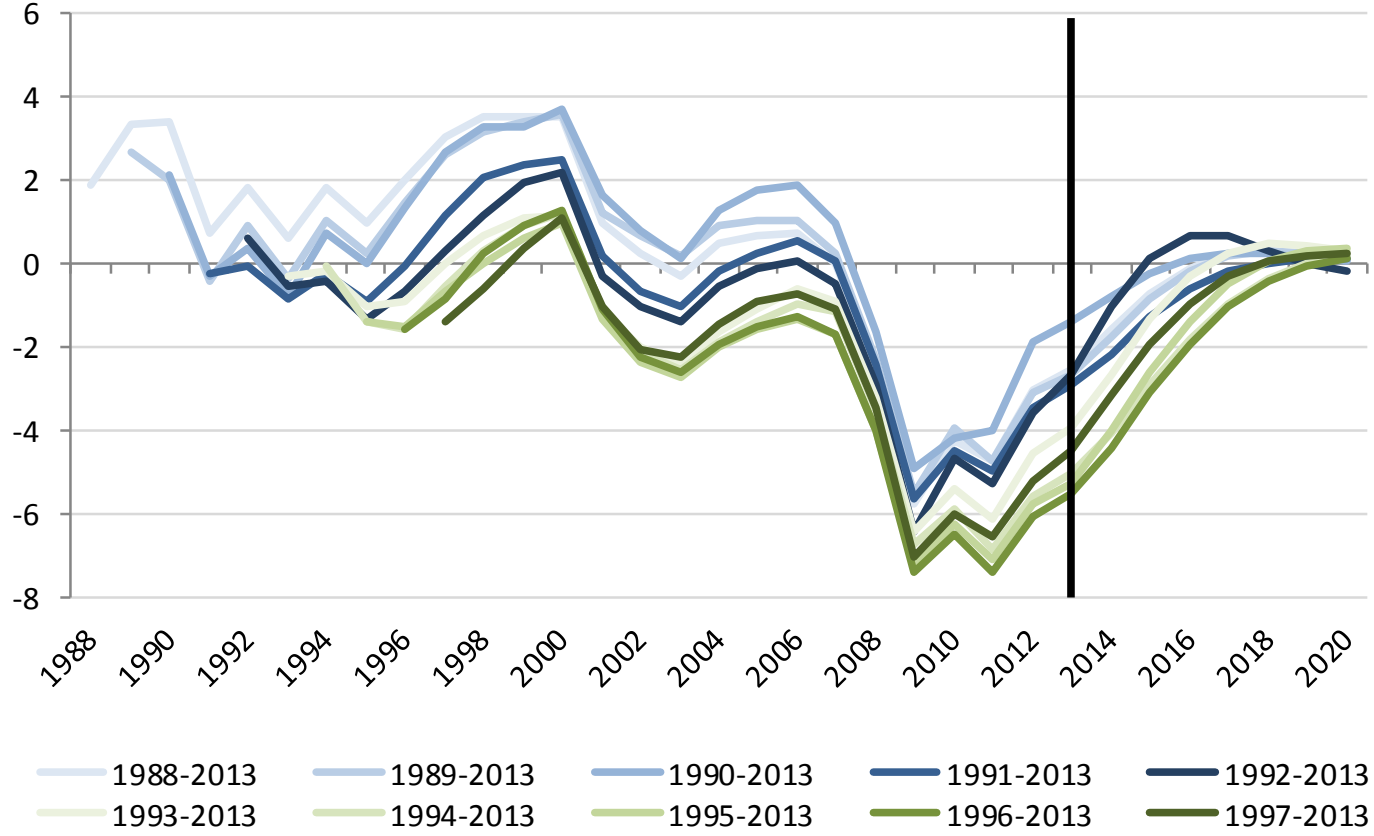
- Starting values for Kalman filter are OLS estimates on HP-filtered data (for example, Kastrati, 2014)

# ***Estimation results***



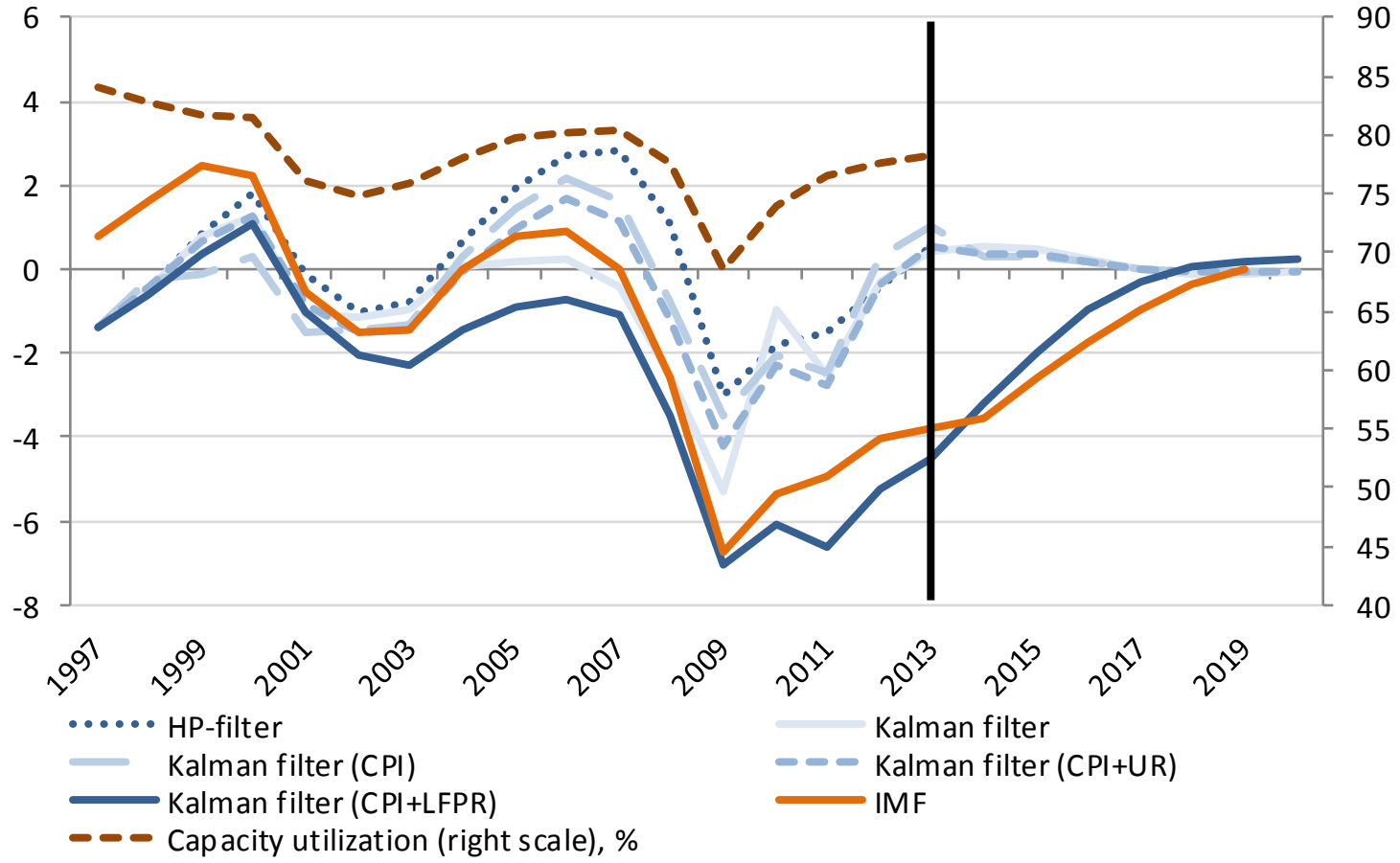
# US Output Gap

Output gap, % GDP  
Trivariate Kalman filter (CPI+LF), different samples



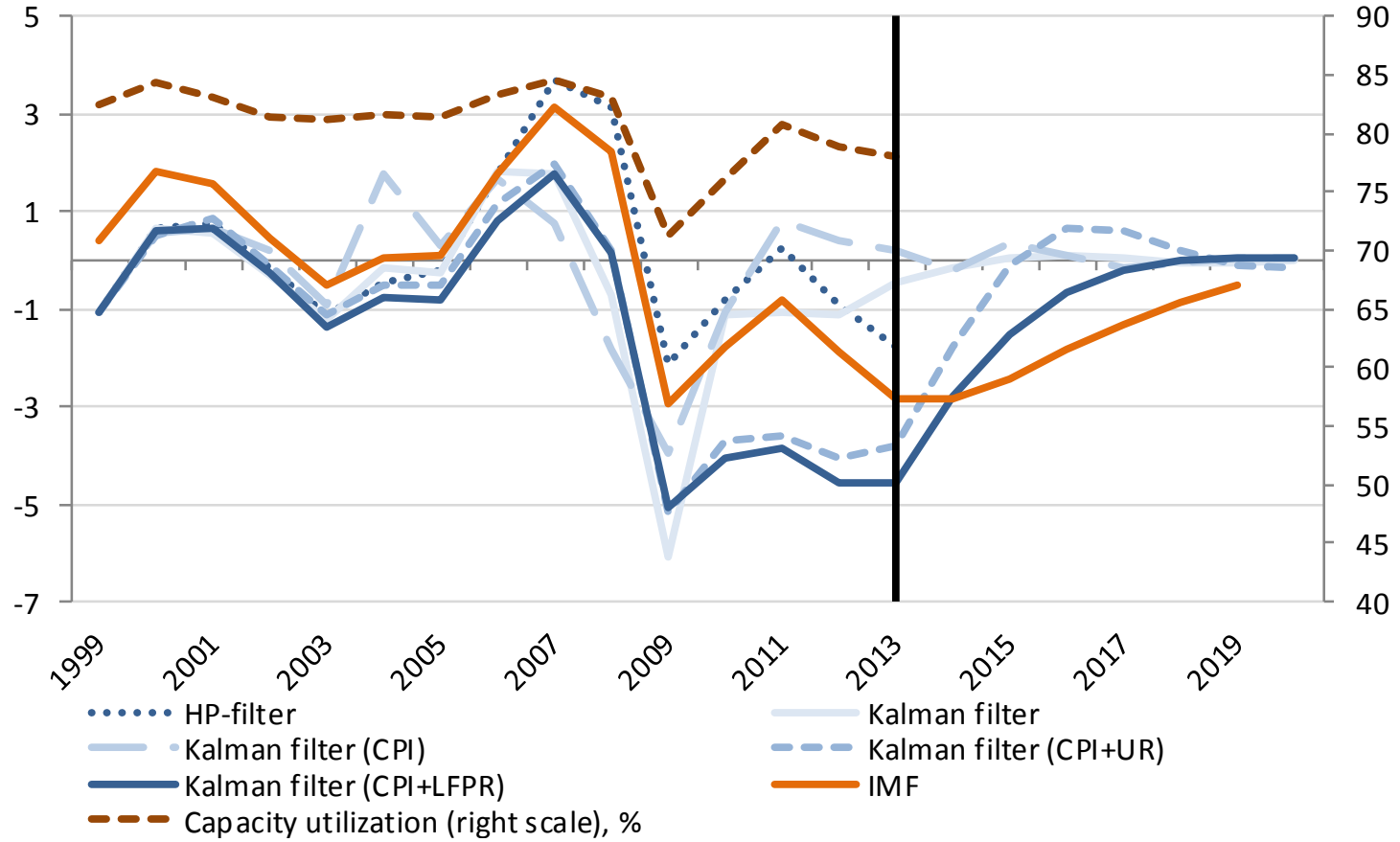
# US Output Gap

Output gap measures, % GDP  
Sample 1997-2013



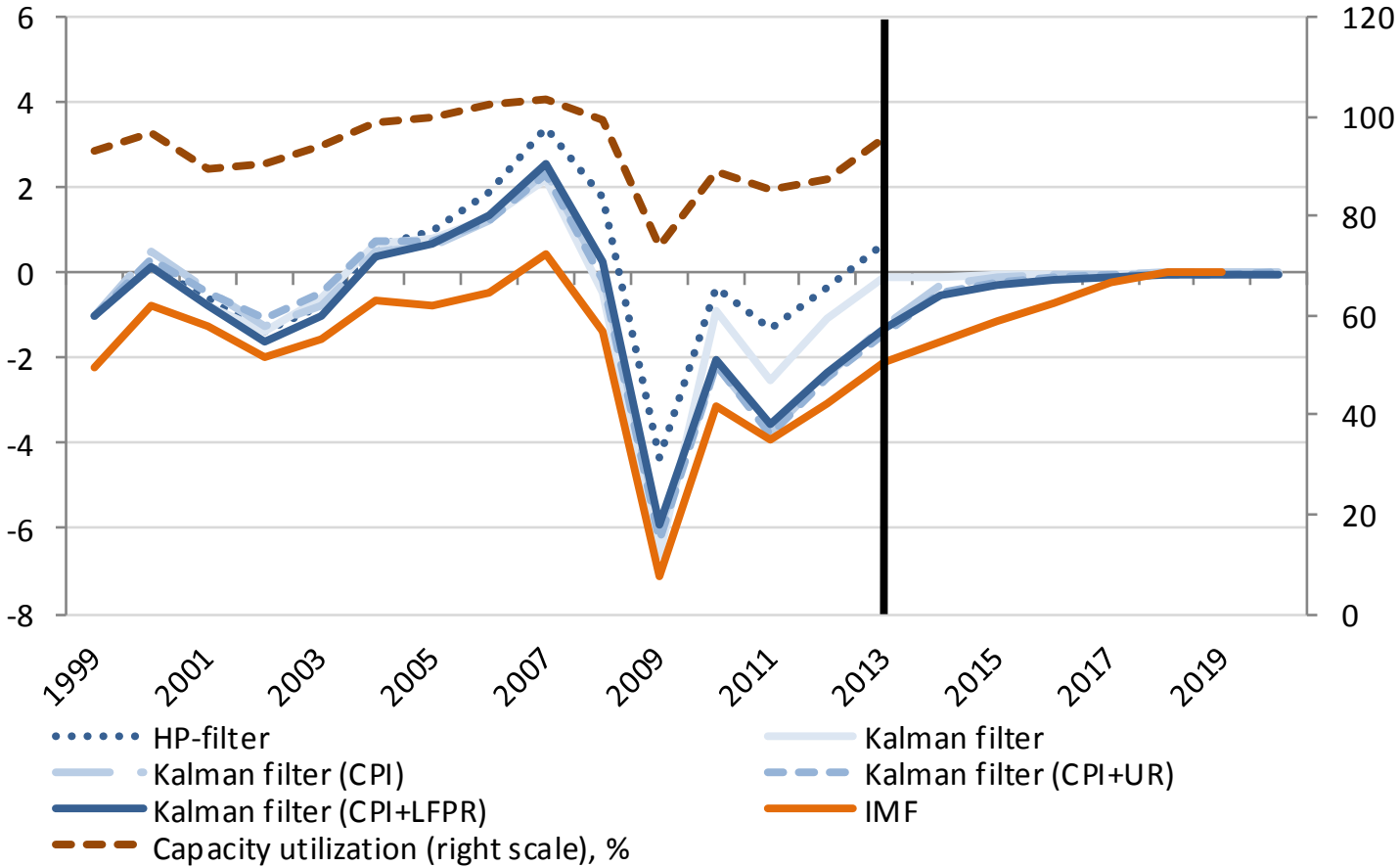
# Euro Area Output Gap

Output gap measures, % GDP  
Sample 1999-2013



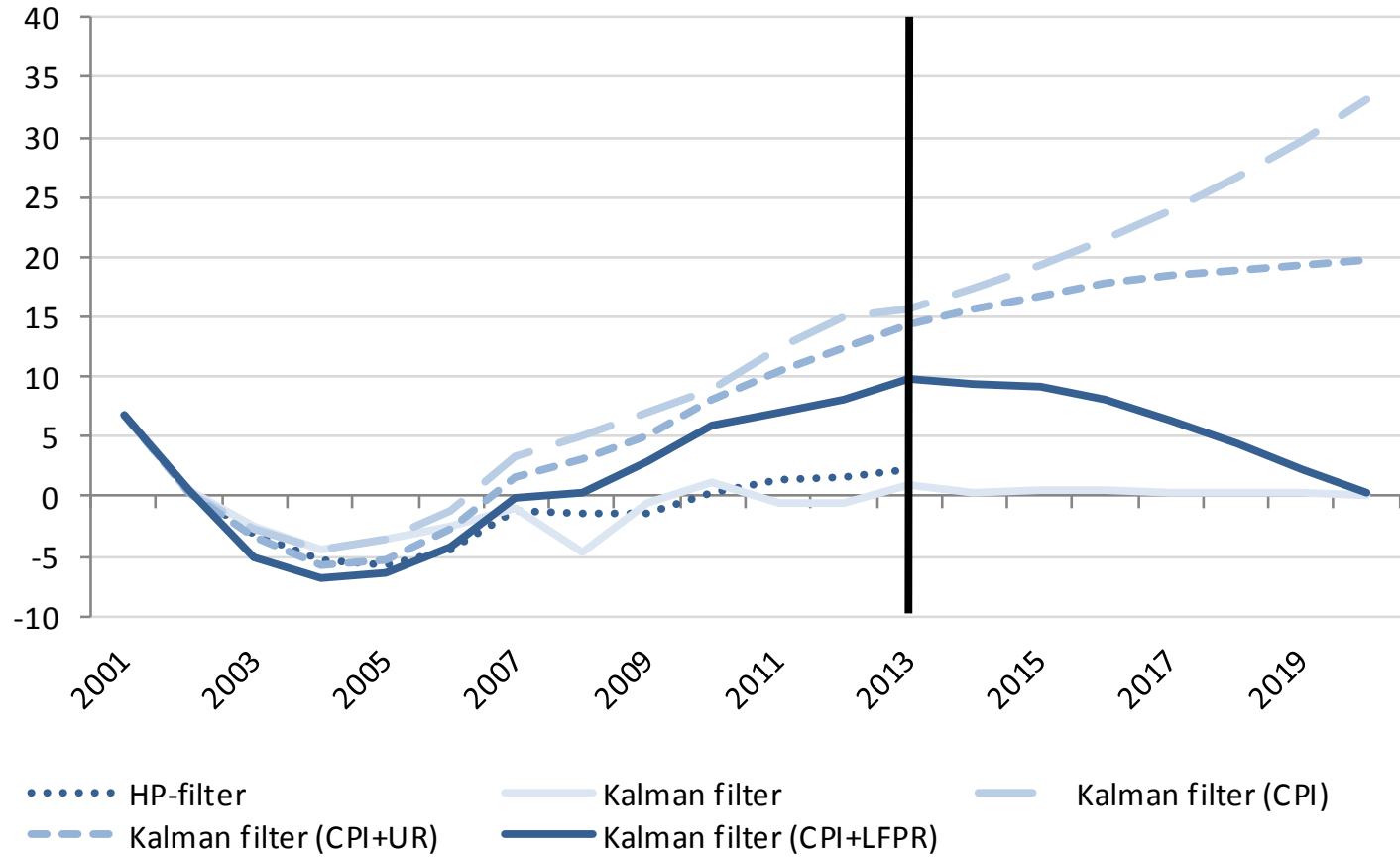
# Japan Output Gap

Output gap measures, % GDP  
Sample 1999-2013



# China Output Gap

Output gap measures, % GDP  
Sample 2001-2013



# ***Testing for structural breaks***

## ***Testing for structural breaks (1)***

- Is the «New Normal» period a structural slowdown?
- Potential GDP for euro area, Japan and China slowed considerably post-crisis
- Chinese GDP correction may intensify in case of investment normalisation (currently investment is near 50% GDP)

### ***Actual vs Potential GDP growth, %***

<b>Economies</b>	<b>Actual</b>		<b>Potential</b>	
	<b>2000-2007</b>	<b>2011-2013</b>	<b>2000-2007</b>	<b>2011-2013</b>
<b>US</b>	<b>2.7</b>	<b>2.0</b>	<b>2.8</b>	<b>1.5</b>
<b>Euro area</b>	<b>2.2</b>	<b>0.2</b>	<b>1.8</b>	<b>0.3</b>
<b>Japan</b>	<b>1.5</b>	<b>0.8</b>	<b>1.1</b>	<b>0.6</b>
<b>China</b>	<b>10.5</b>	<b>8.2</b>	<b>12.5</b>	<b>6.9</b>

## Testing for structural breaks (2)

- **Testing for structural breaks can be done in 3 cases :**
  - ✓ we know exact years of probable breaks (Chow, 1960)
  - ✓ we know only maximum number of breaks (Bai, Perron, 2003)
  - ✓ we know nothing about breaks (Chen, Liu, 1993)
- We test each year for structural breaks in the series of potential GDP with **Bai-Perron test**

Type of filter	US	Euro area	Japan	China
	1997-2013	1999-2013	1999-2013	2001-2013
Kalman filter (CPI+LFPR)	2005, 2009	2003, 2009	2003, 2009	2005, 2009
Kalman filter (CPI+UR)	2002, 2009	2006, 2009	2004, 2009	2005, 2009
Kalman filter (CPI)	2002, 2009	2005, 2009	2003, 2009	2005, 2008
Kalman filter	2002, 2009	2007, 2010	2010	2005, 2009
HP-filter	2003, 2007	2006, 2009	2006, 2009	2004, 2009

- Bai-Perron test results robust to filter choice.
- **Chen-Liu test** indicates about break in euro area in 2011 (Level Shift) and also in Japan in 2011 (Temporary Change)



- **The «New normal» can be inferred from data as a structural slowdown from 2009-2010 onwards**
- **Despite our lower estimates of output gap, forecasts for output gap closing dates are more optimistic than IMF**
- **There is still large cyclical component (output gap), which should recede by 2017 for US, EA and Japan (for the latter – in case of successful structural reforms) and by 2020 for China**
- **Demand stimulation measures are potentially effective but for China, which runs huge excess supply (currently about 10%), mostly because of structural overinvestment**
- **Chen-Liu test argues break existence only in euro area in 2011 (Level Shift – B. Gross) and in Japan in 2011 (Temporary Change – not “New normal”)**

Thanks for your attention!