Global Projection Model (GPM):Structure and Applications

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Workshop on GPM
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Roadmap

- Background and motivation
- Stages in model building
- The Structure of the Model
- Confronting model with data
- Applications

Background and motivation

Two types of models developed by the IMF in recent years and used in central banks and by country desks

- A small quarterly projection model (QPM) with 4 or 5 key equations (Berg, Karam and Laxton)
- A DSGE models – based on theoretical underpinnings and optimization by various participants in the economy

To develop a series of country or regional small macro models incorporating real and financial linkages.

Background and motivation cont.

- To develop a series of country or regional small macro models incorporating real and financial linkages.
- Use these models to explain past developments and to forecast the world economy

GPM aims at providing consistent international forecasts

At present, projections at policymaking institutions of the external outlook usually take the following approaches:

- Use forecasts from commercial sources, including from think tanks and global banks
- Use forecasts prepared by international organizations
- Build internal models

Potential sources of concern with these approaches

- Consistency at the global level
- Timing and frequency of forecast updates
- Resource constraints to develop macro models
- How to implement risk analysis

- Currently GPM is in a quarterly production cycle
- Many uses in the WEO and EWE

- Potential Output

$$\overline{Y}_{i,t} = \overline{Y}_{i,t-1} + g_{i,t}^{\overline{Y}}/4 + \varepsilon_{i,t}^{\overline{Y}} \tag{1}$$

$$g_{i,t}^{\overline{Y}} = \tau_i g_i^{\overline{Y}_{ss}} + (1-\tau_i) g_{i,t-1}^{\overline{Y}} + \varepsilon_{i,t}^{g^{\overline{Y}}} \tag{2}$$

- NAIRU

$$\overline{U}_{i,t} = \overline{U}_{i,t-1} + g_{i,t}^{\overline{U}} + \varepsilon_{i,t}^{\overline{U}} \tag{3}$$

$$g_{i,t}^{\overline{U}} = (1-\alpha_{i,3}) g_{i,t-1}^{\overline{U}} + \varepsilon_{i,t}^{g^{\overline{U}}} \tag{4}$$

- Equilibrium real interest rate

$$\overline{RR}_{i,t} = \rho_i \overline{RR}_{i,SS} + (1-\rho_i)\overline{RR}_{i,t-1} + \varepsilon_{i,t}^{\overline{RR}} \tag{5}$$

- Equilibrium real exchange rate

$$LZ_{i,t} = 100 * log(S_{i,t} P_{us,t}/P_{i,t}) \tag{6}$$

$$\Delta LZ_{i,t} = 100\Delta log(S_{i,t}) - (\pi_{i,t} - \pi_{us,t})/4 \tag{7}$$

$$\overline{LZ}_{i,t} = \overline{LZ}_{i,t-1} + \varepsilon_{i,t}^{\overline{LZ}} \tag{8}$$

We introduce two types of effects to the traditional open economy output gap equation

- Real-Financial linkages
- Real international spillovers

Real -Financial Linkages

- Introduction of Bank Lending Tightening variable

$$BLT_{US,t} = \overline{BLT}_{US,t} - \kappa_{US} y_{US,t+4} - \varepsilon^{BLT}_{US,t}$$

$$\overline{BLT}_{US} = \overline{BLT}_{US,t-1} + \varepsilon^{\overline{BLT}}_{US,t}$$

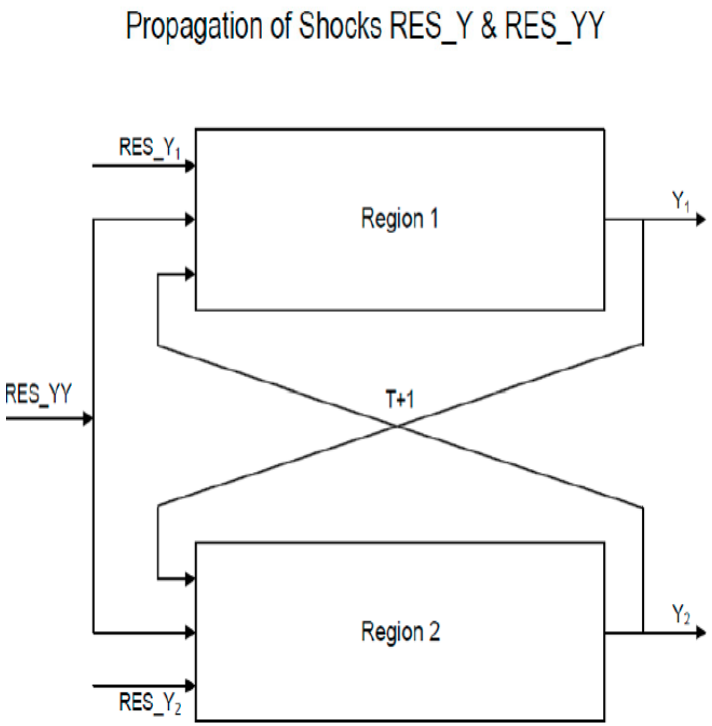
$$\begin{aligned} y_{US,t} &= \beta_{US,1} y_{US,t-1} + \beta_{US,2} y_{US,t+1} - \beta_{US,3} r_{US,t-1} \\ &+ \beta_{US,4} \sum_j \omega_{US,4,j} z_{US,j,t-1} \\ &+ \beta_{US,5} \sum_j \omega_{US,j,5} y_{j,t-1} + \theta_{US} \eta_{US,t} + \varepsilon^{y}_{US,t} \end{aligned}$$

$$\begin{aligned} \eta_{US,t} &= 0.04\varepsilon^{BLT}_{US.t-1} + 0.08\varepsilon^{BLT}_{US,t-2} + 0.12\varepsilon^{BLT}_{US,t-3} + 0.16\varepsilon^{BLT}_{US,t-4} + 0.2 \\ &+ 0.16\varepsilon^{BLT}_{US,t-6} + 0.12\varepsilon^{BLT}_{US,t-7} + 0.08\varepsilon^{BLT}_{US,t-8} + 0.04\varepsilon^{BLT}_{US,t-9} \end{aligned}$$

Spillover Channels

- Direct through foreign output gaps
- Indirect through Global demand shocks; financial channels in the Non-G3; Other traditional channels (Exchange rate, inflation, interest rate)

GPM features two types of Demand Shocks



- **Idiosyncratic demand shock (RES Y)**
- Originates in a particular block
- Propagates to the other blocks via the output gap over time. Example: Increase in business and consumer confidence in the US, which subsequently propagates to the other economies via output gap or trade
- **Global and instantaneous shocks (RES YY)**
- These shocks might originate in a particular block (ex. stock market shock in the US triggering chain reactions; sovereign market distress in Europe)
- It captures everything which is subject to contagion besides traditional dynamics
- These shocks might be truly global (ex. Global Oil shock)
- Apply instantaneously to all blocks.

- Output Gap in G3 economies

$$
\begin{aligned}
y_{i,t} \quad = \quad & \{\beta_{i,1} y_{i,t-1} + \beta_{i,2} y_{i,t+1} - \beta_{i,3} mrr_{i,t-1}\} \\
& + \{\beta_{i,4} \sum_j \omega_{i,j,4} (z_{i,j,t-1} + z_{i,j,t-2} + z_{i,j,t-3} + z_{i,j,t-4})/4 \\
& + (\beta_{i,5} \sum_j \omega_{i,j,5} y_{j,t-1} + \sum_i \omega_{i,i,5} \nu_i)\} - \{\theta_i \eta_{i,t}\} + \varepsilon^y_{i,t}
\end{aligned} \tag{9}
$$

- Output Gap in Non-G3 economies

$$
\begin{aligned}
y_{i,t} \quad = \quad & \{\beta_{i,1} y_{i,t-1} + \beta_{i,2} y_{i,t+1} - \beta_{i,3} mrr_{i,t-1}\} \\
& + \{\beta_{i,4} \sum_j \omega_{i,j,4} (z_{i,j,t-1} + z_{i,j,t-2} + z_{i,j,t-3} + z_{i,j,t-4})/4 \\
& + (\beta_{i,5} \sum_j \omega_{i,j,5} y_{j,t-1} + \sum_i \omega_{i,i,5} \nu_i)\} - \{\theta_i \sum_j \omega_{i,j,5} \eta_{j,t}\} + \varepsilon^y_{i,t}
\end{aligned} \tag{10}
$$

- Inflation

$$\pi_{i,t} = \lambda_{i,1}\pi 4_{i,t+4} + (1-\lambda_{i,1})\pi 4_{i,t-1} + \lambda_{i,2} y_{i,t-1} + \lambda_{i,3} \sum_{j} \omega_{i,j,3}(z_{i,j,t} - z_{i,j,t-4})/4 \tag{11}$$

- Policy Interest Rate

$$I_{i,t} = (1-\gamma_{i,1})\left[\overline{R}_{i,t} + \pi 4_{i,t+3} + \gamma_{i,2}(\pi 4_{i,t+3} - \pi_i^{tar}) + \gamma_{i,4} y_{i,t}\right] + \gamma_{i,1} I_{i,t-1} + \varepsilon^{I}_{i,t} \tag{12}$$

- Uncovered Interest Rate Parity

$$(RR_{i,t} - RR_{us,t}) = 4(LZ^{e}_{i,t+1} - LZ_{i,t}) + (\overline{RR}_{i,t} - \overline{RR}_{us,t}) + \varepsilon^{RR-RR_{us}}_{i,t} \quad (13)$$

$$LZ^{e}_{i,t+1} = \phi_i \; LZ_{i,t+1} + (1 - \phi_i) \; LZ_{i,t-1} \quad (14)$$

- Unemployment Rate

$$u_{i,t} = \alpha_{i,1} u_{i,t-1} + \alpha_{i,2} y_{i,t} + \varepsilon^{u}_{i,t} \quad (15)$$

Advantages of Bayesian Methods

- Puts some weight on priors and some weight on the data
- Incorporates theoretical insights to prevent incorrect empirical results (such as interest rate movements having perverse effects on inflation), but also confronts model with the data to some extent
- Allows use of small samples without concern about incorrect estimated results
- Allows estimation of many coefficients and latent variables (e.g., output gap, NAIRU, equilibrium real interest rate) even in small samples

By specifying tightness of distribution on priors, researcher can change relative weights on priors and data in determining posterior distribution for parameters.

Very difficult to estimate simultaneously all parameters (169) and shocks (71) We proceeded in stages:

- Previous GPM studies
- Strong priors (e.g. spillover formulation)
- Currently 10 parameters and all shocks are estimated.

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GPM6 Parameters [1]

			US	Euro Area	Japan	EA6	LA6	RC6
GDP		% share of world GDP, PPP	22.488	16.265	6.485	28.440	7.013	16.469
Steady State Values								
		GDP Growth	2.273	2.261	1.444	6.000	6.000	6.000
		Real Interest Rate	1.728	1.984	1.379	2.000	2.000	2.000
		Inflation Target	2.500	1.900	1.000	4.000	3.500	4.500
Trend Coefficients								
	τ	Potential Output	0.027	0.029	0.037	0.030	0.030	0.030
	ρ	Real Interest Rate	0.290	0.467	0.030	0.200	0.200	0.200
	χ	Real Exchange Rate				0.050	0.050	0.050
Output Gap								
	β_1	Lag	0.569	0.756	0.779	0.471	0.544	0.441
	β_2	Lead	0.231	0.044	0.021	0.215	0.178	0.408
	β_3	Long-run interest rate gap	0.187	0.201	0.148	0.200	0.200	0.200
	β_4	REER gap	0.051	0.067	0.036	0.171	0.148	0.070
	β_5	Foreign Activity	0.891	0.891	0.891	0.891	0.891	0.891
	θ	BLT	1.071	0.300	0.300	0.996	0.992	0.996
Headline Inflation								
	λ_1	Lead	0.750	0.700	0.750	0.720	0.594	0.545
	λ_2	Output gap	0.180	0.222	0.184	0.197	0.228	0.149
	λ_3	REER gap	0.100	0.246	0.152	0.081	0.161	0.098
Monetary Policy Rule								
	γ_1	Lag	0.711	0.686	0.750	0.667	0.645	0.725
	γ_2	Inflation gap	0.910	1.306	1.058	1.114	0.911	0.898
	γ_4	Output gap	0.205	0.201	0.169	0.169	0.202	0.162
UIP								
	ϕ	Exp Change in Exch Rate		0.834	0.856	0.800	0.800	0.800
Unemployment		Dynamic Okuns Law						
	α_1	Lag	0.824	0.717	0.759			
	α_2	Output gap	0.182	0.140	0.060			
	$(1\text{-}\alpha_3)$	Trend coefficient	0.635	0.899	0.779			
Med Term Interest Rate		Weights						
	ξ_1	1 qtr ahead	0.100	0.100	0.100	0.100	0.100	0.100
	ξ_4	1 yr ahead	0.350	0.350	0.350	0.350	0.350	0.350
	ξ_{12}	3 yrs ahead	0.350	0.350	0.350	0.350	0.350	0.350
	ξ_{20}	5 yrs ahead	0.200	0.200	0.200	0.200	0.200	0.200

[1] Estimated parameters are in green. Partially estimated (GPM3 or 4) are in red. Calibrated parameters are in black.

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GPM6 Trade and Spillovers Table

		US	Euro Area	Japan	EA6	LA6	RC6
GDP	% share of world GDP, PPP	22.488	16.265	6.485	28.440	7.013	16.469
Exports	Aggregate (% of GDP)	0.074	0.124	0.149	0.201	0.165	0.171
GPM6 Trade Weights							
	to US	...	0.202	0.284	0.366	0.687	0.369
	to EU	0.168	...	0.131	0.228	0.111	0.452
	to JA	0.077	0.038	...	0.196	0.029	0.044
	to EA6	0.190	0.133	0.457	...	0.062	0.108
	to LA6	0.178	0.039	0.021	0.031	...	0.027
	to RC6	0.386	0.588	0.106	0.179	0.112	...
Imports	Aggregate (% of GDP)	0.127	0.129	0.111	0.161	0.161	0.182
GPM6 Trade Weights							
	from US	...	0.113	0.149	0.205	0.422	0.207
	from EU	0.154	...	0.106	0.212	0.145	0.489
	from JA	0.084	0.051	...	0.307	0.058	0.049
	from EA6	0.315	0.259	0.532	...	0.243	0.208
	from LA6	0.148	0.048	0.041	0.053	...	0.047
	from RC6	0.299	0.529	0.173	0.222	0.132	...
Rel. Country Size							
	to US	...	0.810	0.350	0.430	0.170	0.610
	to EU	1.230	...	0.430	0.520	0.200	0.750
	to JA	2.830	2.310	...	1.210	0.470	1.730
	to EA6	2.350	1.910	0.830	...	0.390	1.440
	to LA6	6.050	4.920	2.130	2.570	...	3.700
	to RC6	1.640	1.330	0.580	0.700	0.270	...
Spillovers							
	to US	1.000	0.016	0.008	0.019	0.015	0.030
	to EU	0.030	1.000	0.006	0.022	0.006	0.083
	to JA	0.037	0.019	1.000	0.075	0.005	0.019
	to EA6	0.097	0.066	0.050	1.000	0.016	0.056
	to LA6	0.094	0.025	0.008	0.018	1.000	0.026
	to RC6	0.065	0.094	0.012	0.026	0.006	1.000

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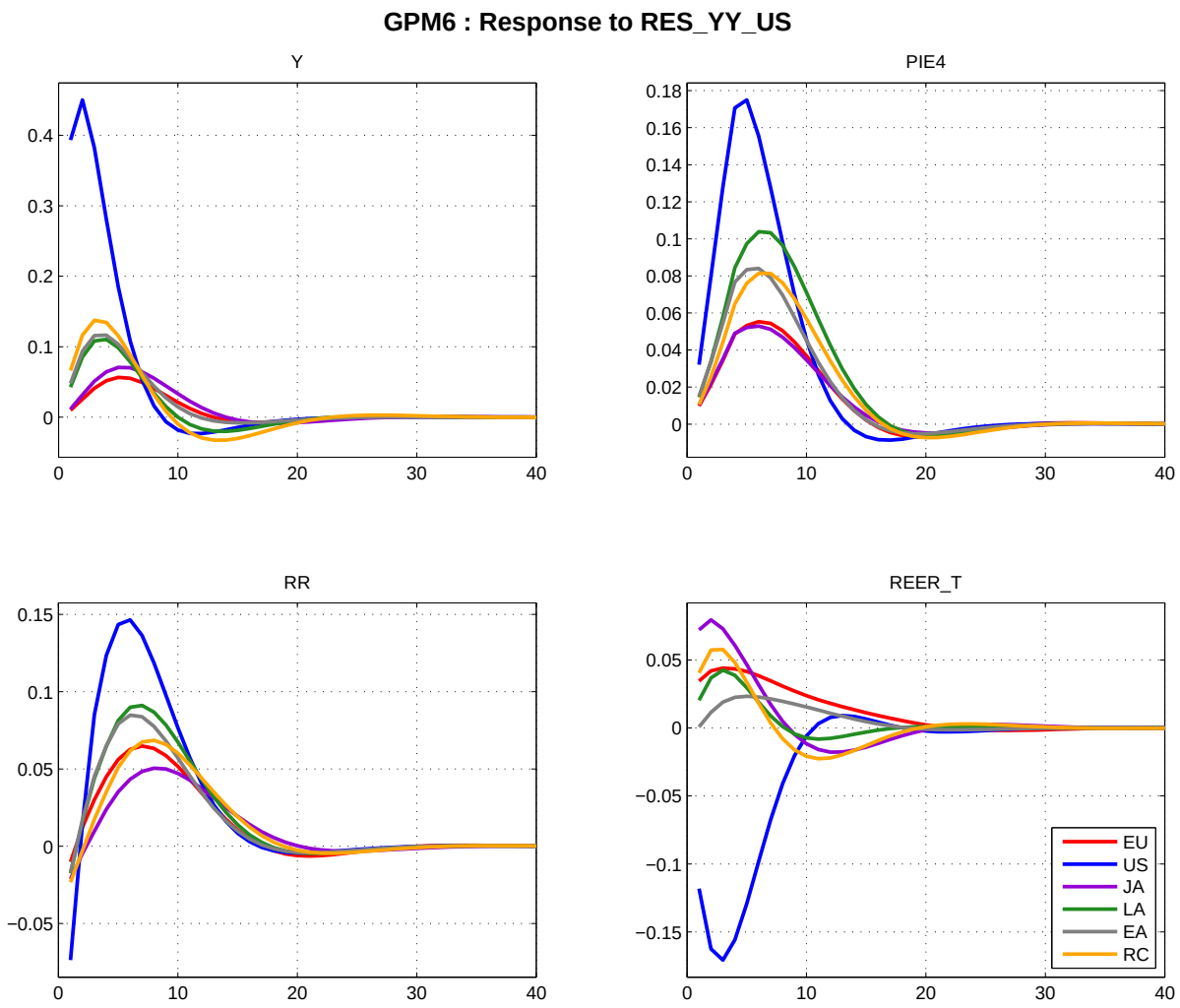

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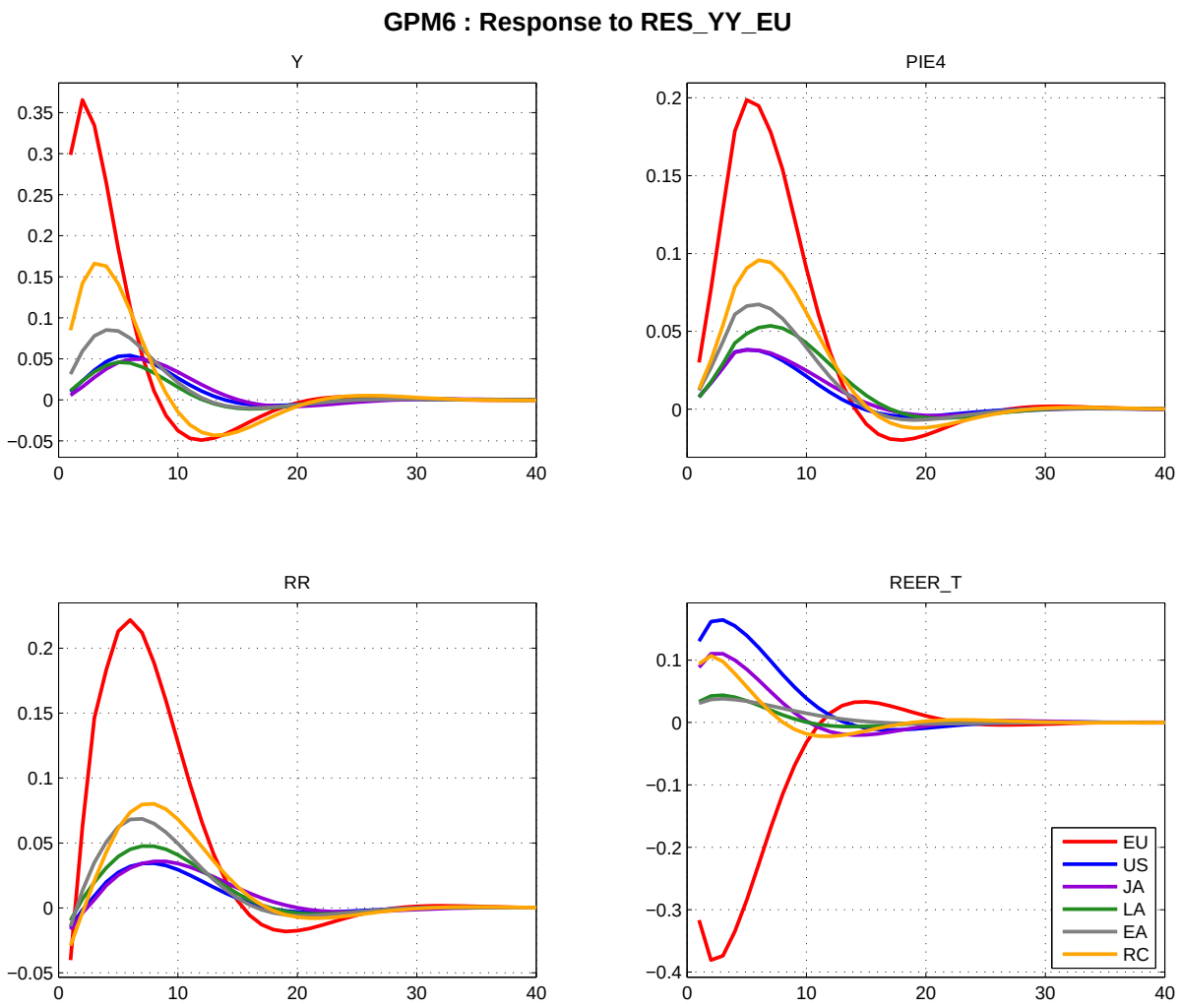

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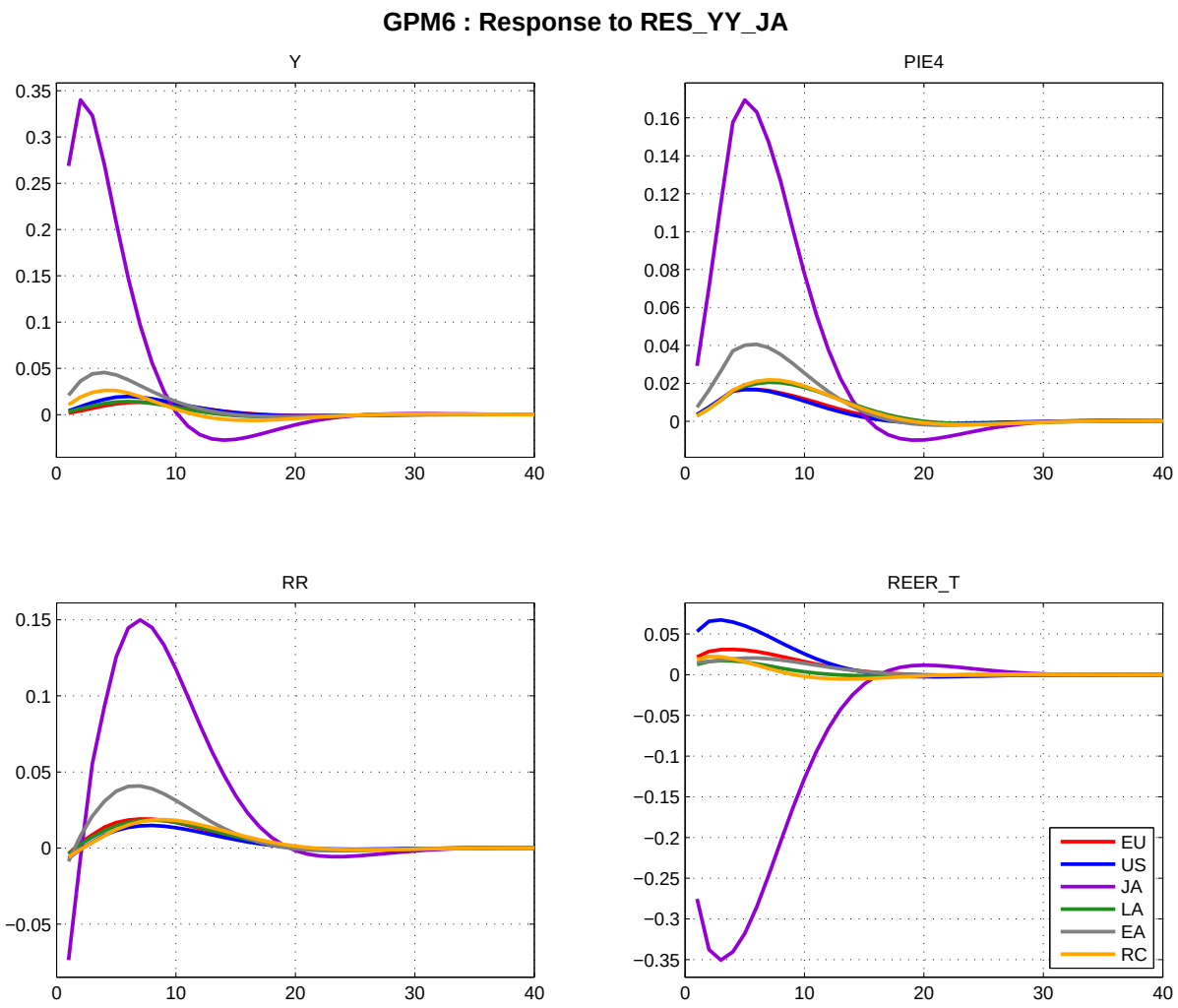

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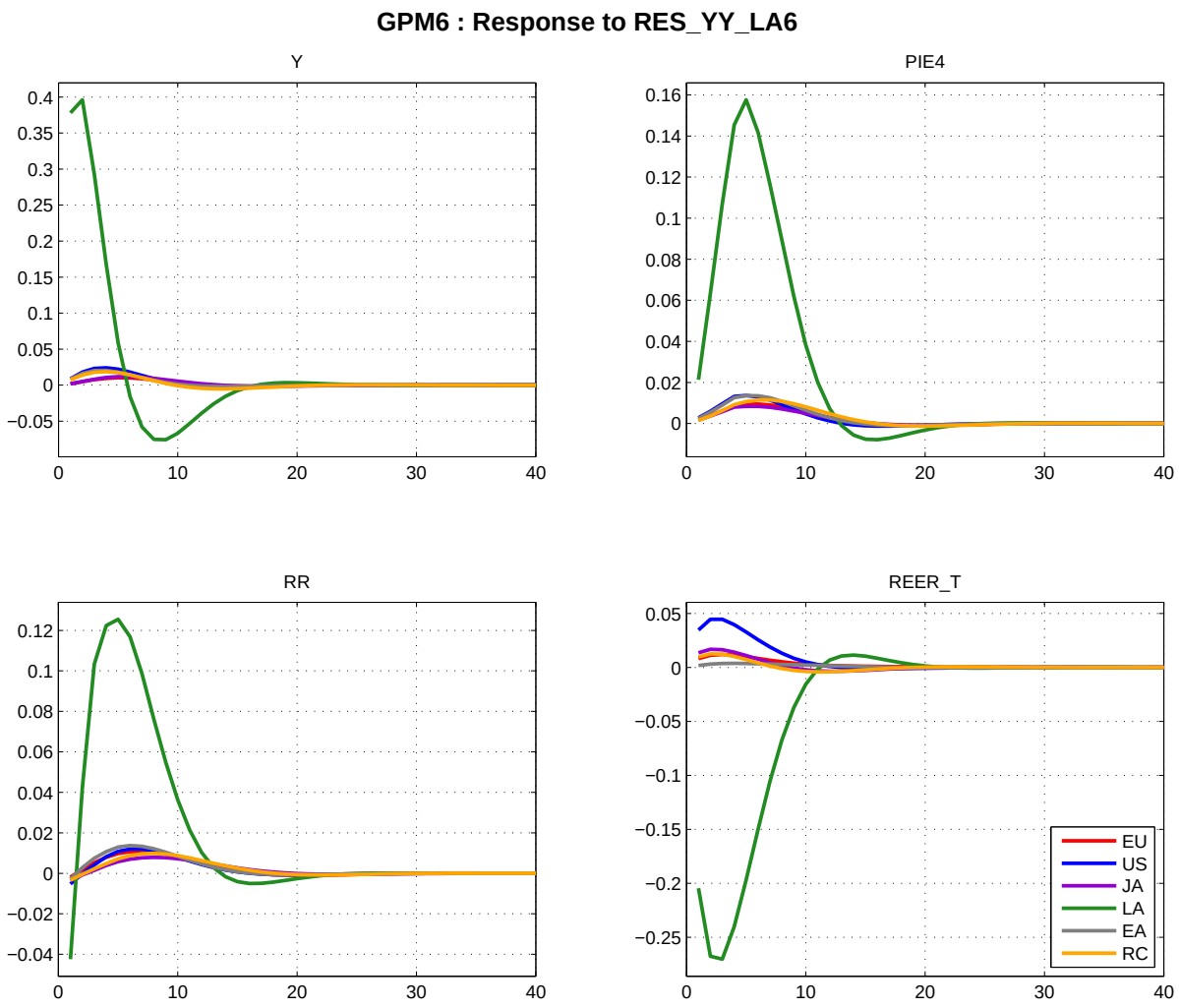

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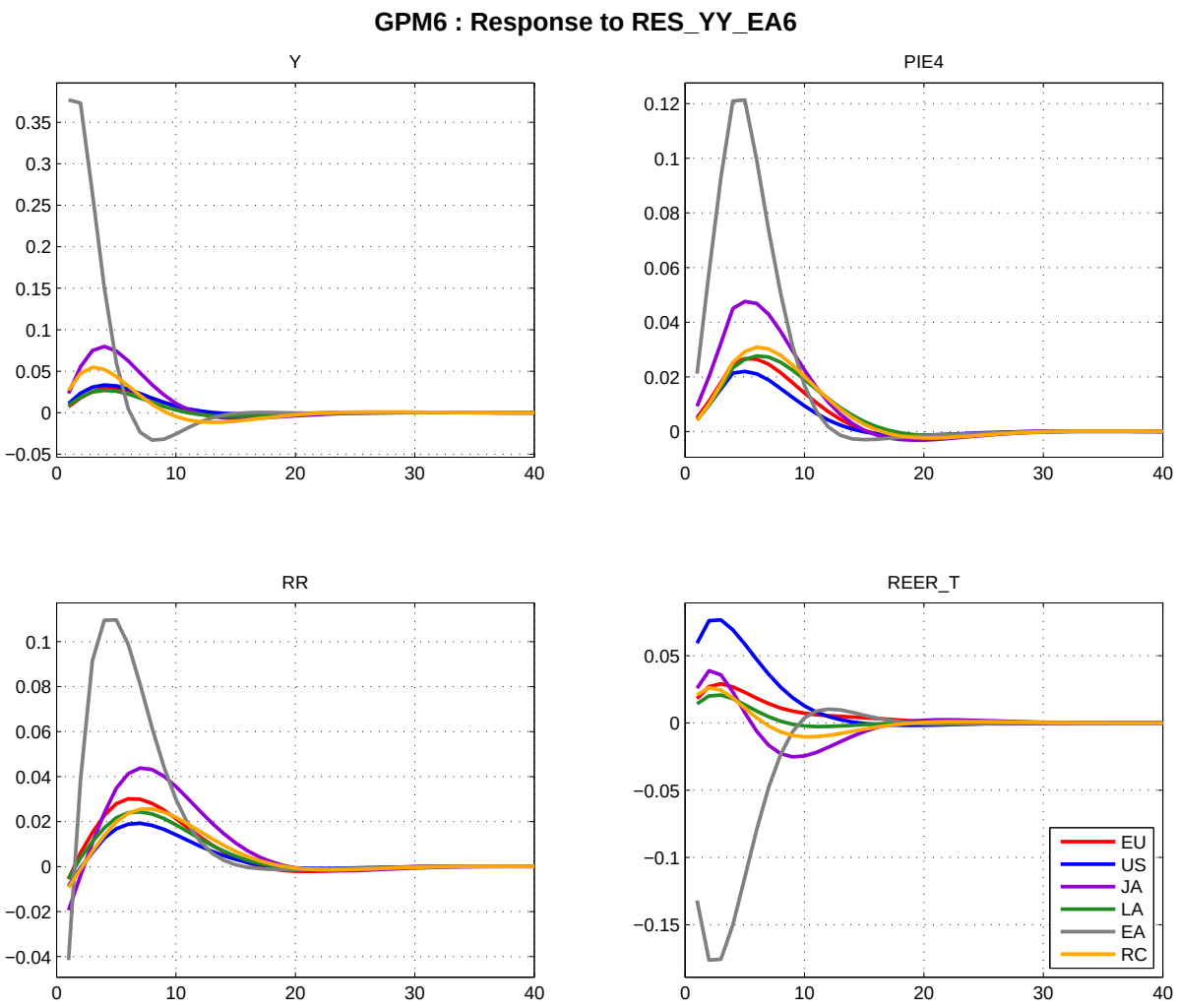

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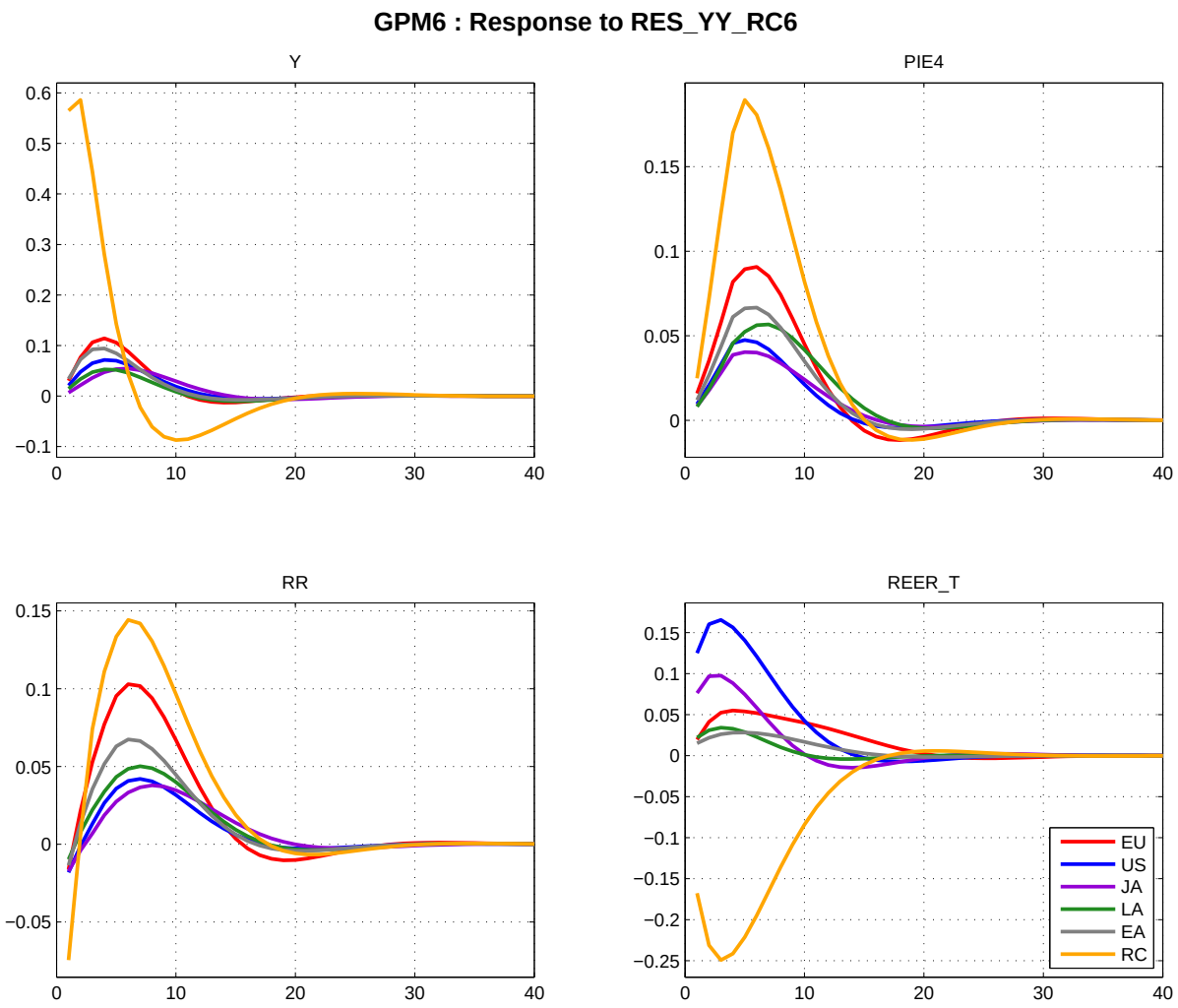
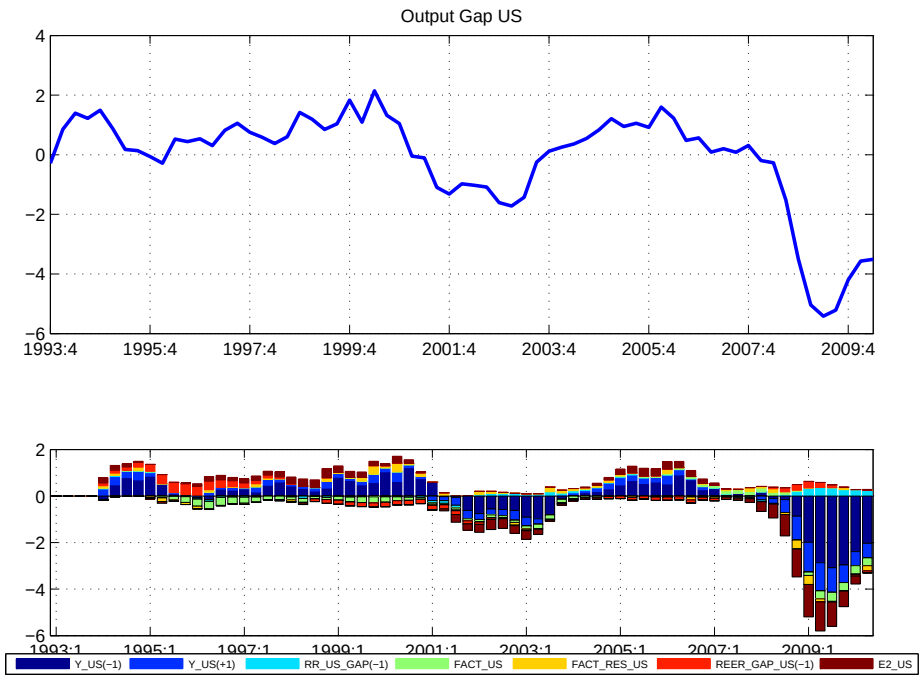
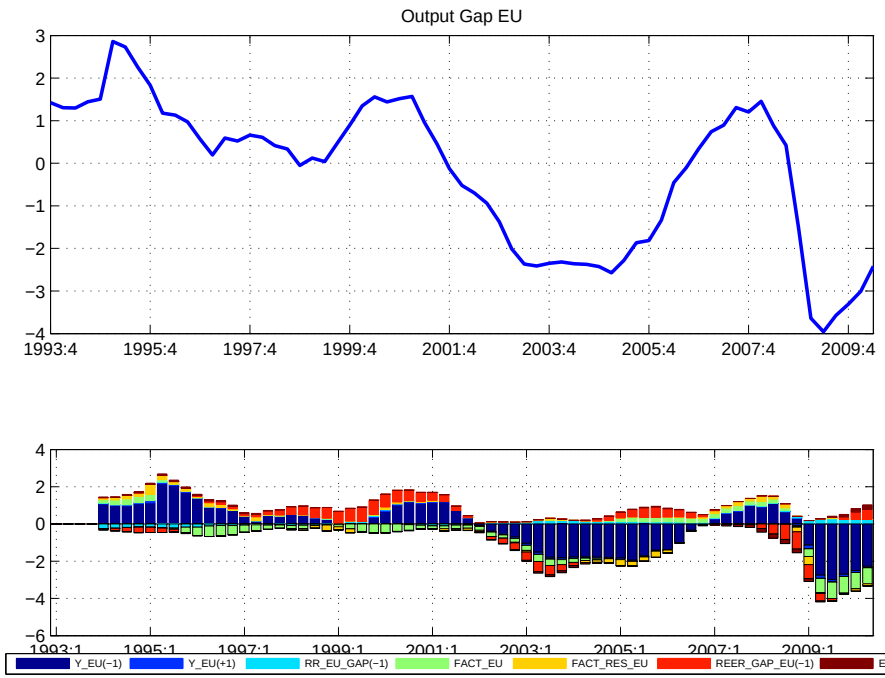



Output Gap US
Y_US(−1)
Y_US(+1)
RR_US_GAP(−1)
FACT_US
FACT_RES_US
REER_GAP_US(−1)
E2_US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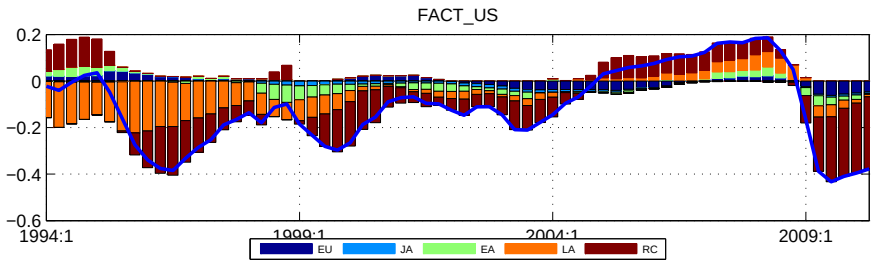
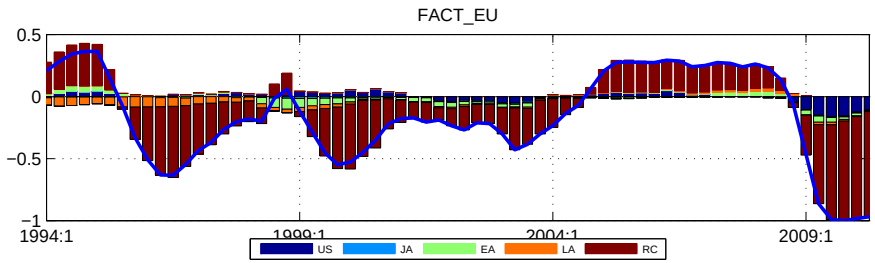
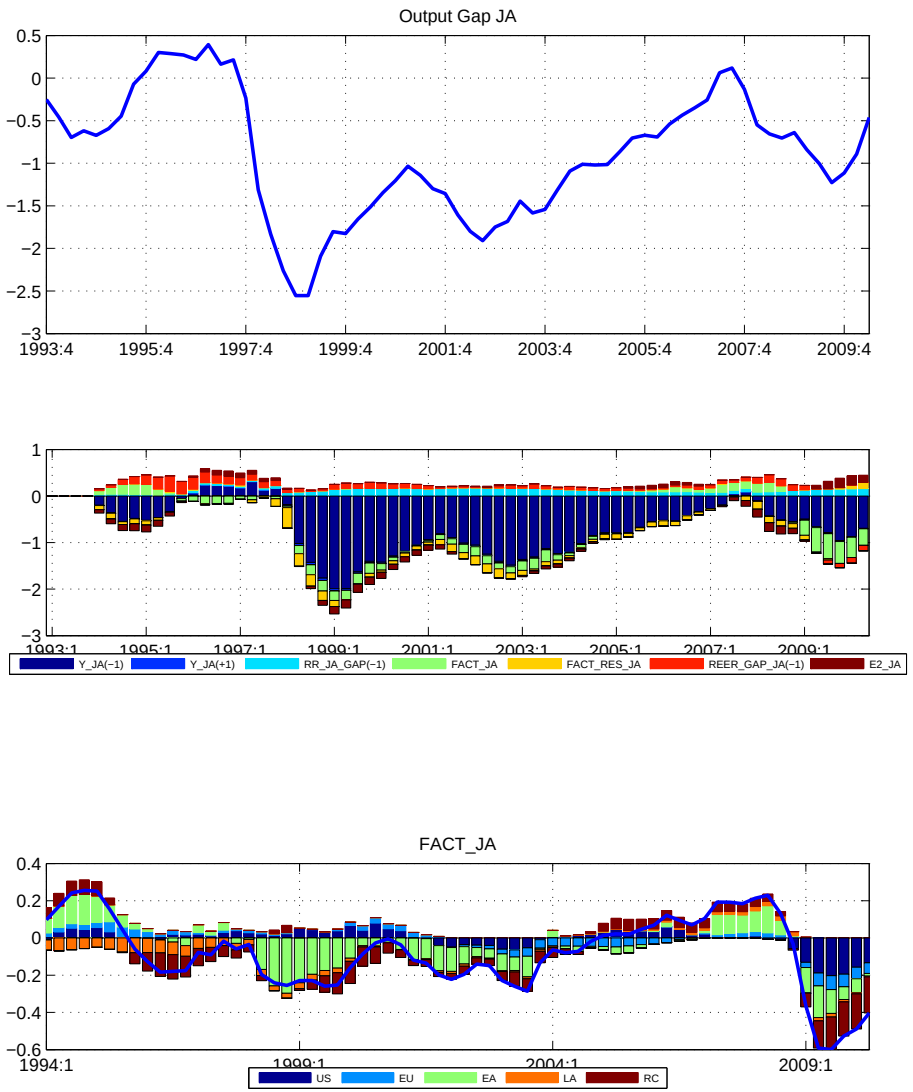
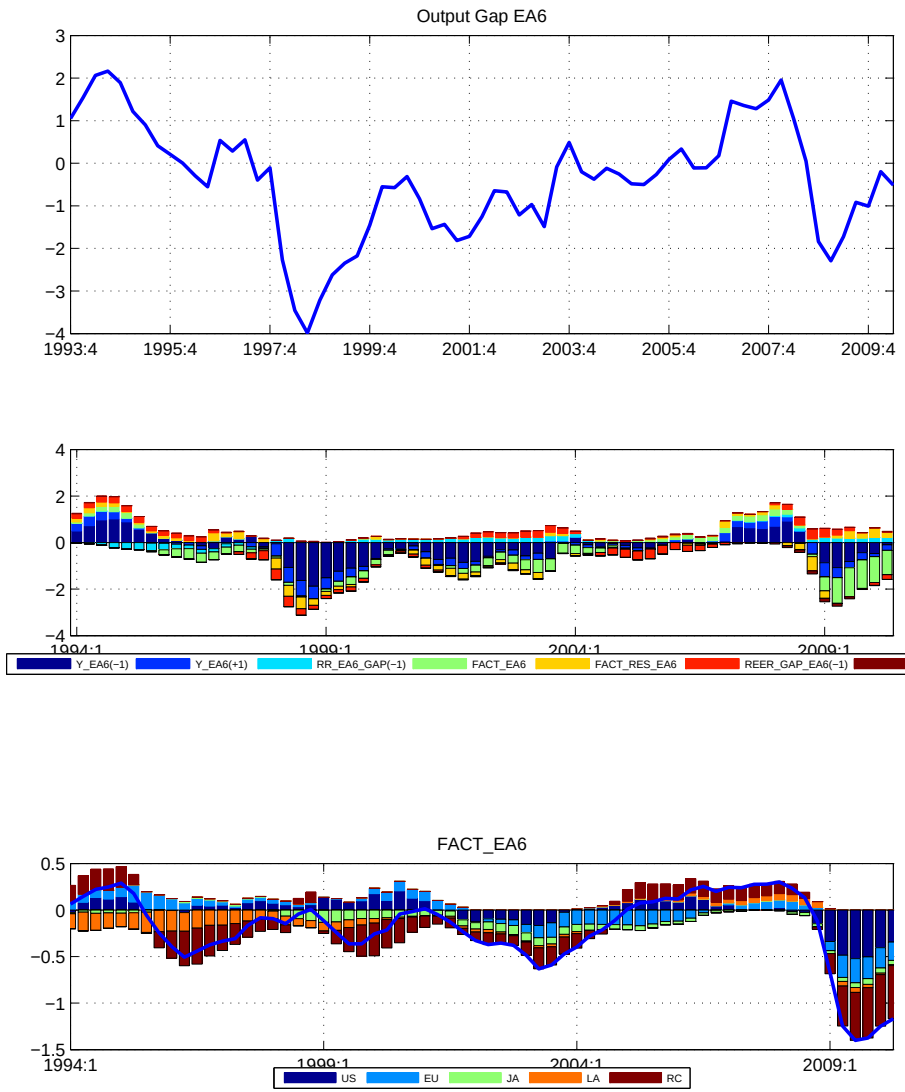
Y_EU(+1)
RR_EU_GAP(−1)
FACT_EU
FACT_RES_EU
REER_GAP_EU(−1)


FACT_US
EU
JA
EA
LA
RC


FACT_EU
US
JA
EA
LA
RC


Output Gap JA
Y_JA(−1)
Y_JA(+1)
RR_JA_GAP(−1)
FACT_JA
FACT_RES_JA
REER_GAP_JA(−1)
E2_JA
FACT_JA
US
EU
EA
LA
RC


Output Gap EA6
Y_EA6(−1)
Y_EA6(+1)
RR_EA6_GAP(−1)
FACT_EA6
FACT_RES_EA6
REER_GAP_EA6(−1)
FACT_EA6
US
EU
JA
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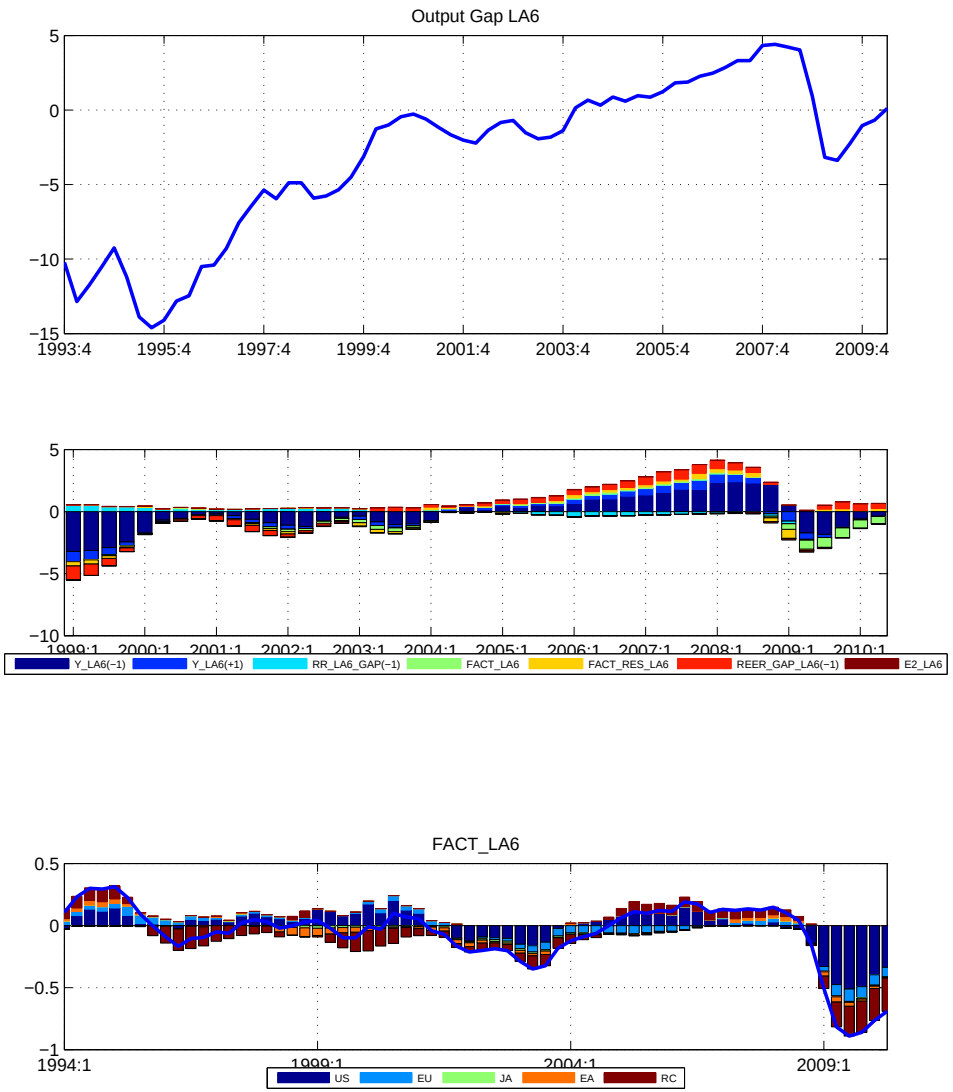
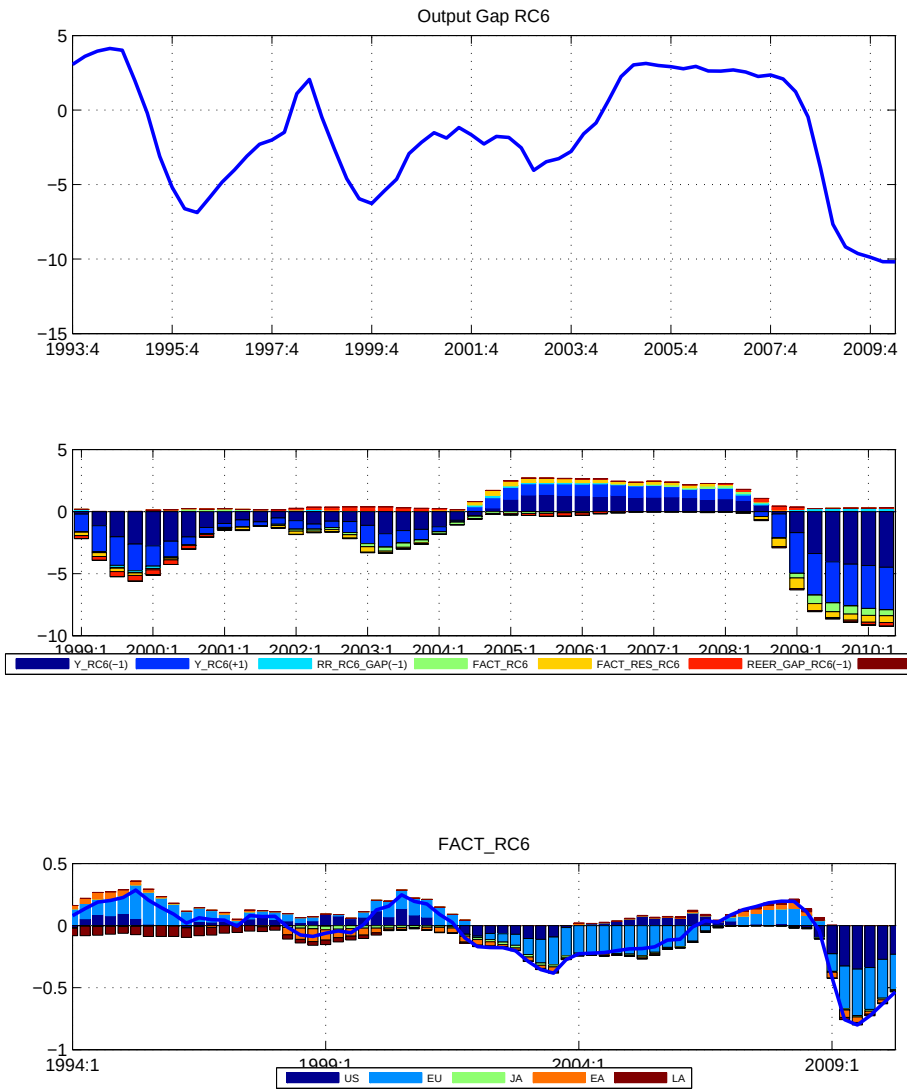
RC


Output Gap LA6
Y_LA6(−1)
Y_LA6(+1)
RR_LA6_GAP(−1)
FACT_LA6
FACT_RES_LA6
REER_GAP_LA6(−1)
E2_LA6
FACT_LA6
US
EU
JA
EA
RC


Output Gap RC6
Y_RC6(−1)
Y_RC6(+1)
RR_RC6_GAP(−1)
FACT_RC6
FACT_RES_RC6
REER_GAP_RC6(−1)
FACT_RC6
US
EU
JA
EA
LA

- Construction of Model Based Forecast to the Global Economy, in support to the WEO
- Creation of Risk Assesments for WEO/WEMD/EWE some REOs
- Collaboration with Area Departments for Article IV consultations

GPM Forecast Update (2010)

Dec09 GPM Projections of Real GDP Growth [a]

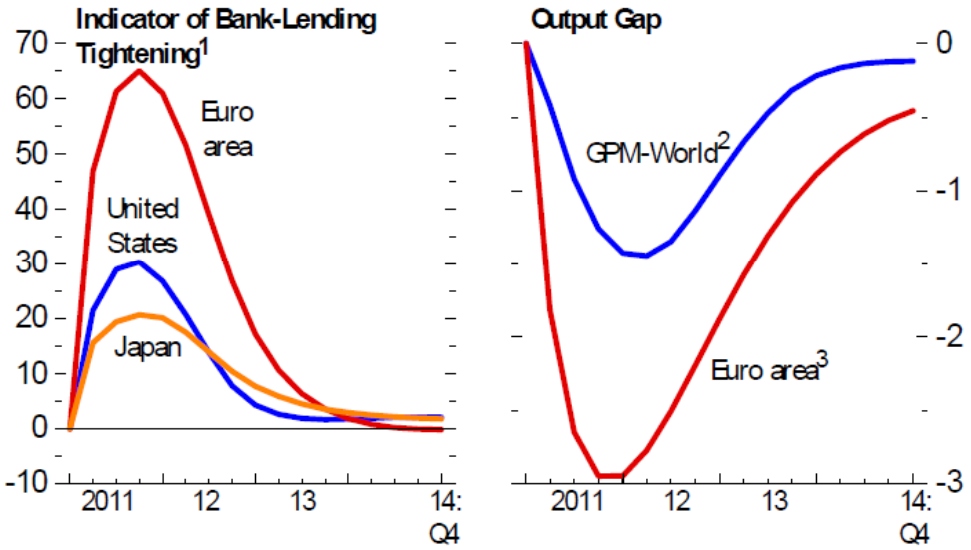
(in percent)

	2010		2010	2011	2012	Difference from Sep 17, 2010				
						2010		2010	2011	2012
	Q3	Q4	Annual	Annual	Annual	Q3	Q4	Annual	Annual	Annual
GPM World (87.5 %) [b]	3.9	3.8	5.0	4.3	4.5	0.4	0.3	0.2	0.3	0.1
United States (20.4 %)	2.5	2.4	2.8	3.1	3.7	1.1	0.3	0.2	0.6	0.2
Euro Area (15.2 %)	1.5	1.2	1.7	1.3	1.9	−0.3	0.5	0.1	0.2	0.1
Japan (6.1 %)	4.5	−1.8	3.6	1.4	2.0	2.9	−2.0	0.7	0.2	0.1
Emerging Asia (24.3 %) [c]	7.6	7.1	9.3	7.8	7.9	0.7	−0.0	0.2	0.3	−0.0
Latin America (6.3 %) [d]	3.1	3.7	6.5	3.8	3.3	1.1	0.5	0.2	0.3	−0.3
Remaining GPM Countries (15.2 %) [e]	1.5	4.7	3.4	3.4	3.4	−1.6	1.5	−0.1	0.1	0.2

[a] These are not official desk forecasts, but preliminary estimates based on GPM6.
[b] Share of world GDP by PPP in parenthesis (2007Y-2010Y average).
[c] Includes: China, Hong Kong SAR, India,Indonesia, South Korea, Malaysia, Philippines, Singapore, Taiwan Province of China, Thailand
[d] Includes: Brazil, Chile, Mexico, Colombia, Peru
[e] Includes: Argentina, Australia, Bulgaria, Canada, Denmark, Estonia, Israel, New Zealand, Norway, Russia, South Africa, Sweden, Switzerland, Turkey, UK and Venezuela

Figure 4. An Alternative Scenario of Intensified Financial Stress in the Euro Area

(Percentage point deviation from baseline)



Source: Global Projection Model GPM simulations.

[1]Bank lending tightness is defined as the unweighted average of the responses to questions with respect to tightening terms and conditions published by the U.S. Federal Reserve's Quarterly Senior Loan Opinion Survey on Bank Lending Practices.

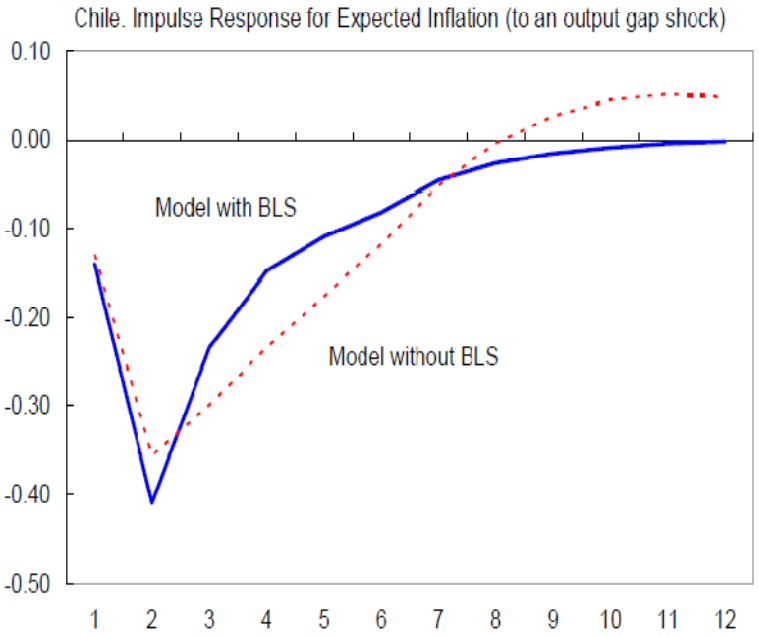
[2]GPM-World represents approximately 87.5 percent of world GDP.

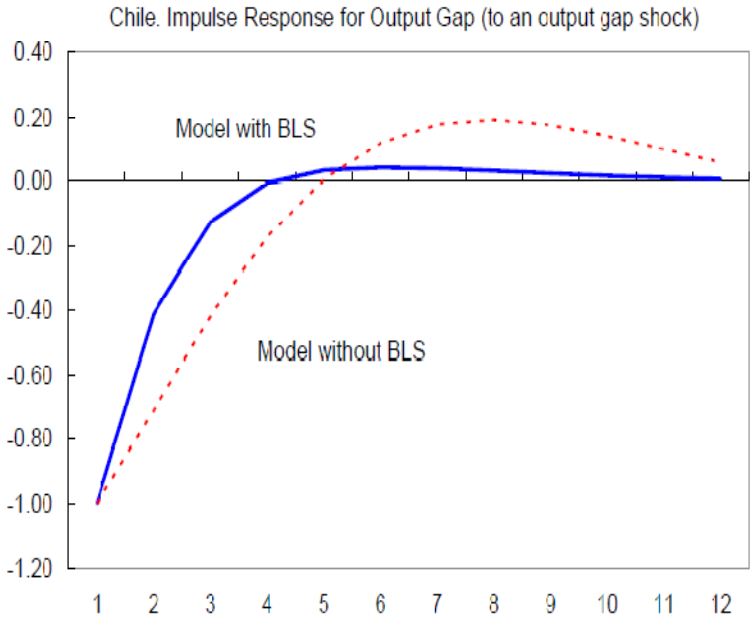
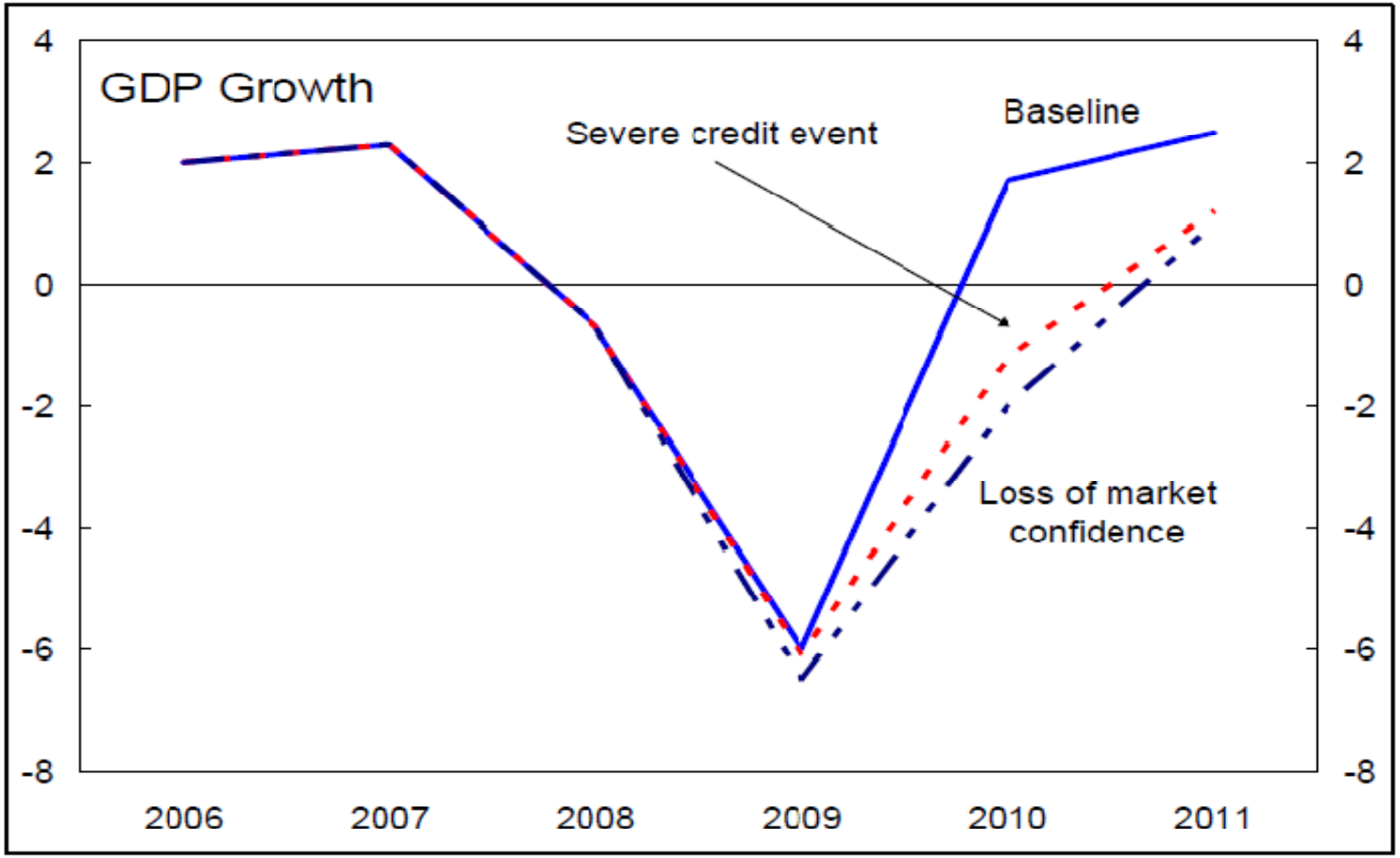
[3]Based on a dynamic stochastic general equilibrium model, supplementing the GPM, that has a risky bank lending and financial accelerator mechanism.

WEO (Jan. 2011, update)

Chile Art. IV (2009, 2010)

Box 3: Bank Lending Conditions and Monetary Policy





Japan (Art. IV, 2009)
Box 1. Analysis of Tail Risk Scenarios