MODELLING THE ROMANIAN YIELD CURVE – A DYNAMIC LATENT FACTOR- NELSON-SIEGEL APPROACH AND THE CONNECTION WITH MACROECONOMICS

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Theme Motivation

- Yield Curve contains information liked to the current stance of monetary and fiscal policy, as well as expectations of future economic activity, real interest rates, and inflation; *overall it represents a benchmark for economy; particularly the slope of the curve is a leading indicator for recession;*

- In Romania, Debts/GDP Ratio stood at 34% (April'2012); 44% of the entire debts is financed by internal sources, namely T-bills/bonds; 80% is accounted by local institutional investors;

- Locally, the total assets of banking system, insurance companies and especially pensions funds (84b lei) is mainly invested in Romanian T-bills/bonds for risk objective and ALM constraints;

- Lately, we assist at a rebalancing of the debts structure: ***improvement of the issues structure***, increasing the medium and long maturities; **2012**: 26% short term bills and 74% long term and medium term bonds vs. 2011: 65,8% short term bills and 82% in 2009.

- Robust construction process of the Yield Curve by the local Ministry of Finance : ~ 4 matt. (points) added on the curve in 2011-2012 period (unfortunately not available for times series);

Literature Review

• **Charles Nelson Andrew Siegel** (**1987**) – "**Parsimonious modeling of yield curve**" provides a remarkably and a wide good fit to the cross section of yields in US bonds market; the model has become a widely used among financial market practitioners and central banks set of papers on this theme are developed and extended starting from NS model.

• **F. Diebold and C. Li (2006) – "Forecasting the term structure of Government bonds yields"** produce term structure forecast at both short and long horizon proving that the model is more accurate on longer horizons.

• **J. Christiansen F. Diebold, G. Rudebusch (2008) |"An Arbitrage-Free Generalized Nelson-Siegel Term Structure Model"-** find that NS model have trouble fitting long-maturity yields. Imposing arbitrage free condition they show that AFGNS model provides a good fit to the yield curve.

• **F. Diebold, G. Rudebusch, S. Arouba (2005) – "The macroeconomics and the yield curve: dynamic latent factors approach" -** examine the dynamic interaction between macroeconomics and the yield curve by incorporating macroeconomic variables into dynamic Nelson Siegel Model framework; he study the bidirectional causality between yield curve and macro economy and find strong evidence of macroeconomic effects on the future yield curve and less-strong evidence of yield curve effects on future macroeconomic activity;

• **Ang. and M. Piazzesi (2003)**: "**A no-arbitrage Vector Autoregressive of the Term Structure dynamic with Macro and latent variable***"* – bonds yields are determined not only by three unobservable factors (Level, slope and curvature) but also by inflation and real activity proving that macro factors explain up to 85% of the movement of the shorts and middle side of the YC; effect of inflation is stronger on the short end of YC. Most movements of long-term bond yields are still accounted for by the unobservable factors; they conclude that macro cannot shift the level of the curve;

• **M. Bech Y. Lengwiler (BIS65):** "**The financial crisis and the changing dynamics of the yield curve" -** *the volatility moved from the short side of the curve on the long end of the curve during "lower bounds phase"* and unconventional monetary policy measures reduces long term yields (Operation Twist and QE1).

Methodology: Three-Factor Yield Curve Model, Two-step approach with a fixed decay parameter (I)

$$y(\tau) = \boldsymbol{\beta}_{1t} + \boldsymbol{\beta}_{2t}\left(\frac{1-e^{-\boldsymbol{\lambda}_t\boldsymbol{\tau}}}{\boldsymbol{\lambda}_t\boldsymbol{\tau}}\right) + \boldsymbol{\beta}_{3t}\left(\frac{1-e^{-\boldsymbol{\lambda}_t\boldsymbol{\tau}}}{\boldsymbol{\lambda}_t\boldsymbol{\tau}} - e^{-\boldsymbol{\lambda}_t\boldsymbol{\tau}}\right)$$

1. **Fix decay parameter λ_t by numerical optimization following standard practice traced by Nesloson-Siegle (1987)**
2. **Estimate, β_1 , β_2 β_3 by cross-sectional OLS:** $Y = X\beta + \mu$

$$\begin{pmatrix} 1 & \frac{1-exp(-\tau_1/\boldsymbol{\lambda})}{\tau_1/\boldsymbol{\lambda}} & \frac{1-exp(-\tau_1/\boldsymbol{\lambda})}{\tau_1/\boldsymbol{\lambda}} - exp(-\tau_1/\boldsymbol{\lambda}) \\ 1 & \frac{1-exp(-\tau_2/\boldsymbol{\lambda})}{\tau_2/\boldsymbol{\lambda}} & \frac{1-exp(-\tau_2/\boldsymbol{\lambda})}{\tau_2/\boldsymbol{\lambda}} - exp(-\tau_2/\boldsymbol{\lambda}) \\ 1 & \frac{1-exp(-\tau_3/\boldsymbol{\lambda})}{\tau_3/\boldsymbol{\lambda}} & \frac{1-exp(-\tau_3/\boldsymbol{\lambda})}{\tau_3/\boldsymbol{\lambda}} - exp(-\tau_3/\boldsymbol{\lambda}) \\ & . & \\ & . & \\ & . & \\ 1 & \frac{1-exp(-\tau_3/\boldsymbol{\lambda})}{\tau_3/\boldsymbol{\lambda}} & \frac{1-exp(-\tau_3/\boldsymbol{\lambda})}{\tau_3/\boldsymbol{\lambda}} - exp(-\tau_3/\boldsymbol{\lambda}) \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix} = \begin{pmatrix} y^M(\tau_1) \\ y^M(\tau_2) \\ y^M(\tau_3) \\ . \\ . \\ . \\ y^M(\tau_m) \end{pmatrix}$$

$$\hat{\beta} = (x'x)^{-1} \quad x' \quad y$$

Methodology: Three-Factor Yield Curve Model, Two-step approach with a fixed decay parameter (II)

3. Forecast NS (latent) Factors by univariate AR(1) Process:

$$\hat{\beta}_{1,t+h/t} = \hat{c}_i + \hat{\gamma}_i \hat{\beta}_{it}, \qquad i = 1,2,3,$$

4. **The yield forecast based on underplaying AR(1) factors specification is:**

$$\hat{y}_{t+h/t}(\tau) = \hat{\beta}_{1,t+h/t} + \hat{\beta}_{2,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \hat{\beta}_{1,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) \qquad \hat{Y}_i = x_i{}' \,\hat{\beta}$$

4. Competitors Models:

a) Random-Walk

$$\hat{y}_{t+h/t}(\tau) = y_t(\tau)$$

b) "Direct regression on three AR(1) principal components"

$$x_t = [x_{1t}, x_{2t}, x_{3t}]$$

$$\hat{x}_{i,t+h/t} = \hat{c}_i + \hat{\gamma}_i x_{it}, \; i = 1,2,3,$$

$$\hat{y}_{t+h/t}(\tau) = q_1(\tau)\hat{x}_{1,t+h/t} + q_2(\tau)\hat{x}_{2,t+h/t} + q_3(\tau)\hat{x}_{3,t+h/t}\,,$$

The Data

- I estimate Nelson-Siegel model using data for the sample period 8M20071M-2M2012 (T = 55 observations) and I use the following cross-sectional data: N = 5 maturities in the estimation: 6,12,36, 60 and 120M months.

- For France, a wide range of cross-sectionals data are used: N=13 maturities: 3M, 6M, 12M, 24M, 36M, 48M, 60M, 72M, 84M, 96M, 108M, 120M over the sample: 2M2002-2M2012 (T=124)

- The yields for the entire maturity spectrum are extracted from Reuters Extra 3000 (already computed); Diebold and Li (2006) used “unsmoothed Famma Bliss method” for yield curve construction;

- The measures for yield curve connection with macroecomics are:
  - INSSE Index 2005=100: monthly consumer price index (CPI) seasonally adjusted and then using log transformation: Log (CPI_t) – $Log(CPI_{t-1})$
  - INSSE Index 2005=100 “Industrial production” using log transformation: (IP) - $Log(CPI_t)$ – $Log(CPI_{t-1})$;
  - Monthly NBR reference rate using log transformation: Log (PR_t) – $Log(PR_{t-1})$.

Econometric program used: Eviews v.7;
Numerical Optimization performed by: http://www.wolframalpha.com/

Estimation Results: Two-step approach with a fixed decay parameter

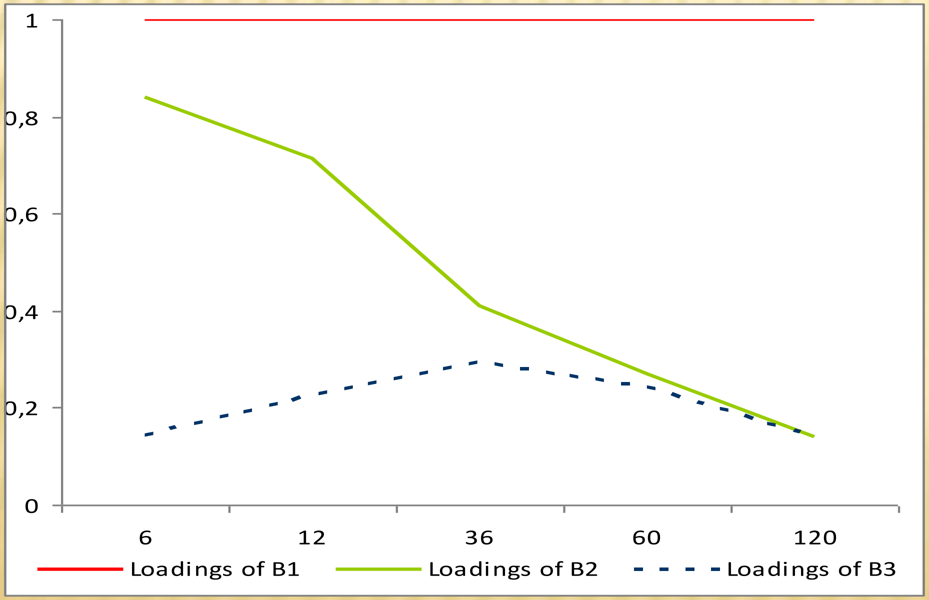
1. The decay parameter λ_t determines the (medium-term) maturity at which the factor loading on the curvature factor β_3- is at its maximum;

2. I fix the decay parameters at **0,0597** by numerical optimization choosing t=30 even if I don't have this matt. on the local market. I have computed the equation loadings repressors, namely X matrix:

3. Nonlinear equations become linear and I can estimate the latent factors using cross-sectional OLS.

4. I check No Multicolinearity assumption, namely: **ρ (x) = K.** Rank of Matrix X = 3 **=>** B_{OLS} is consistent!

Loadings of Latent Dynamic Factors



• β_1 **Loadings** – independent function of Time to maturity and long yield are more persistence than shorts rates -> B1 is the most persistent loading => **Long Term Factors**

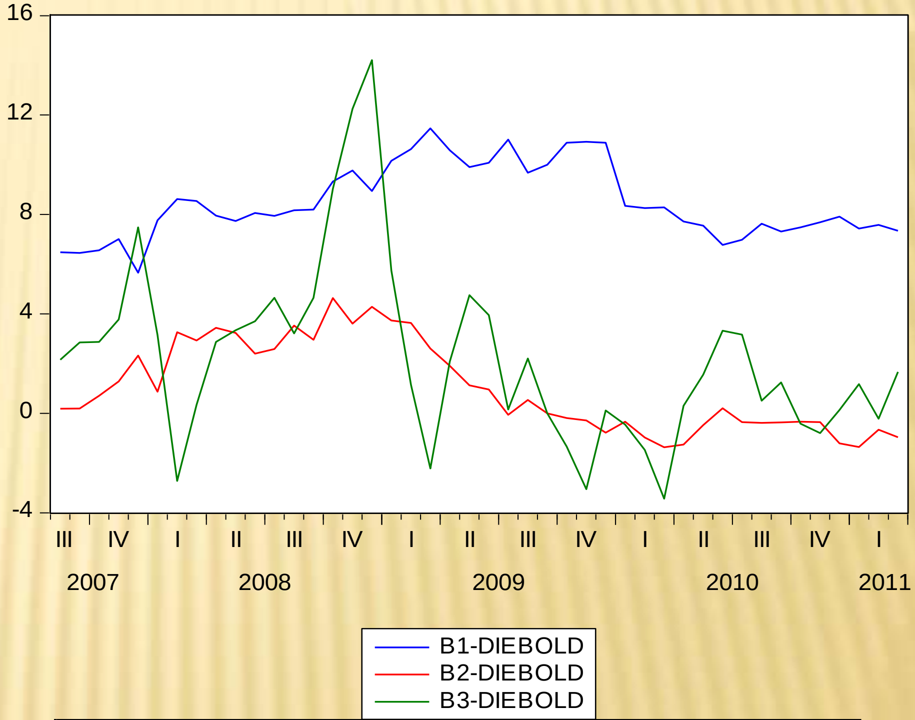
• β_2 **Loadings** – dependent function by time to maturity; it starts from 1 and monotonically decrease to 0 => the influence of β_2 on the short rates is stronger => **Short Term Factors;**

•β_3 **Loadings** - dependent function by time to maturity => **Medium Term Factors**

Characteristics of Latent Factors in a parsimonious model

1. Avg. Slope is positive => curve was inverted;
2. Slope has positive and negative values implying a variety of curve during the sample;
3. Curvature positive => negative butterfly effects; it is the least persistent factors with the highest SD;
4. Yield dynamics are persistent (**β1 Diebold**) + spread is less persistent (**β2 Diebold**);
5. The short side is more volatile than the long side.

Performance of modeled Level, Slope and Curvature (β1 , β2 , β3)



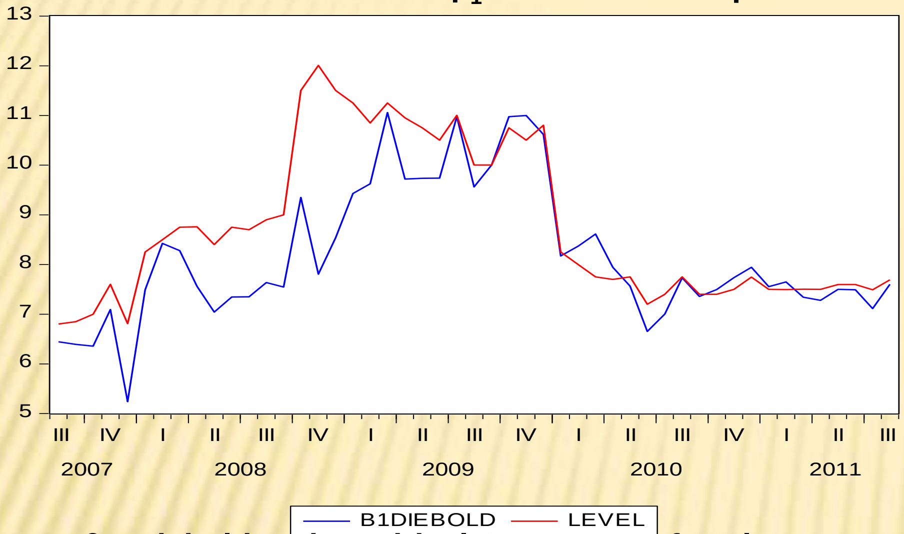
Descriptive statistics for Estimated Beta

	B1_DIEBOLD	B2_DIEBOLD	B3_DIEBOLD
Mean	8.212.735	0.641374	2.373.769
Median	7.718.310	-0.012562	1.885.168
Maximum	1.106.988	6.482.823	1.744.180
Minimum	5.646.648	-2.873.728	-3.866.575
Std. Dev.	1.275.844	2.292.222	3.643.701
Skewness	0.781152	0.674144	1.732.187
Kurtosis	2.808.884	2.301.006	7.848.079
Jarque-Bera	5.677.186	5.285.670	8.136.736
Probability	0.058508	0.071159	0.000000

Correlation Probability	B1_DIEBOLD	B2_DIEBOLD	B3_DIEBOLD
B1_DIEBOLD	1.000.000		
B2_DIEBOLD	0.214825	1.000.000	
	0.1614	-----	
B3_DIEBOLD	-0.113271	0.606353	1.000.000
	0.4641	0.0000	-----

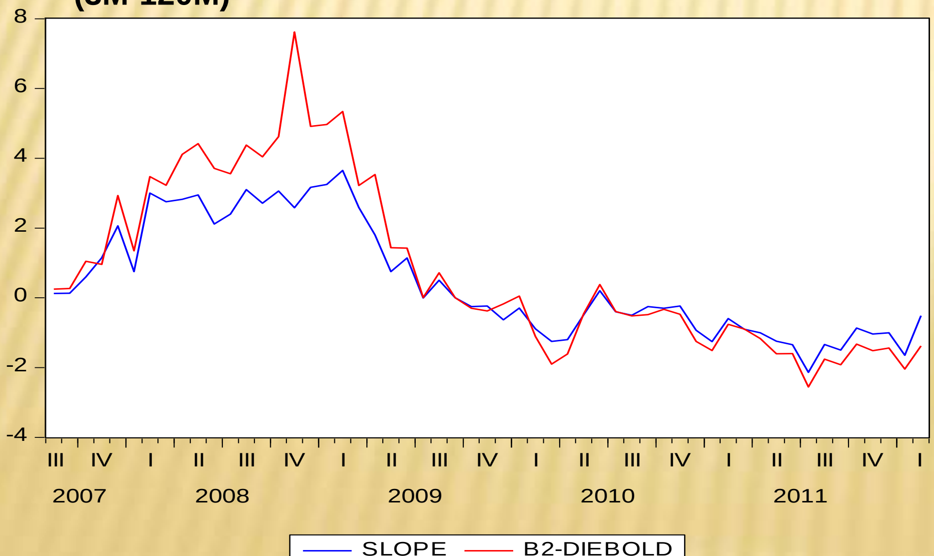
Empirical Counterparts (Level, slope and curvature) and its correlation with the modeled "latent Factors"

β_1-Diebold and empirical Counterpart for Level (120M)

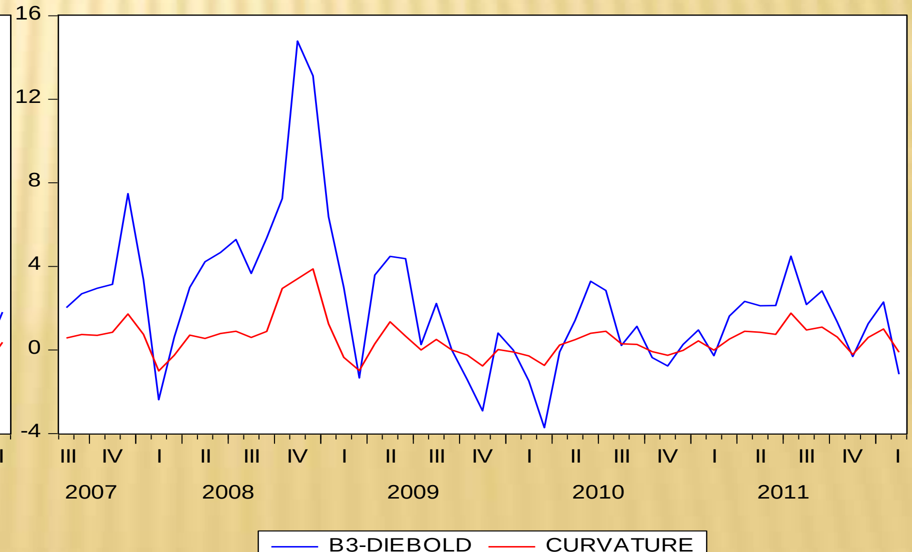


Correlation Probability	B1_DIEBOLD	B2_DIEBOLD	B3_DIEBOLD
LEVEL	***0.806762***		
	0.0000		
SLOPE	0.033270	***0.959607***	
	0.8302	**0.0000**	
CURVATURE	-0.267859	0.520073	**0.934223**
	0.0788	0.0003	**0.0000**

β_2 -Diebold and empirical Counterpart for Slope (3M-120M)



β_3-Diebold and empirical Counterpart for Curvature (2x36M-3M-120M)

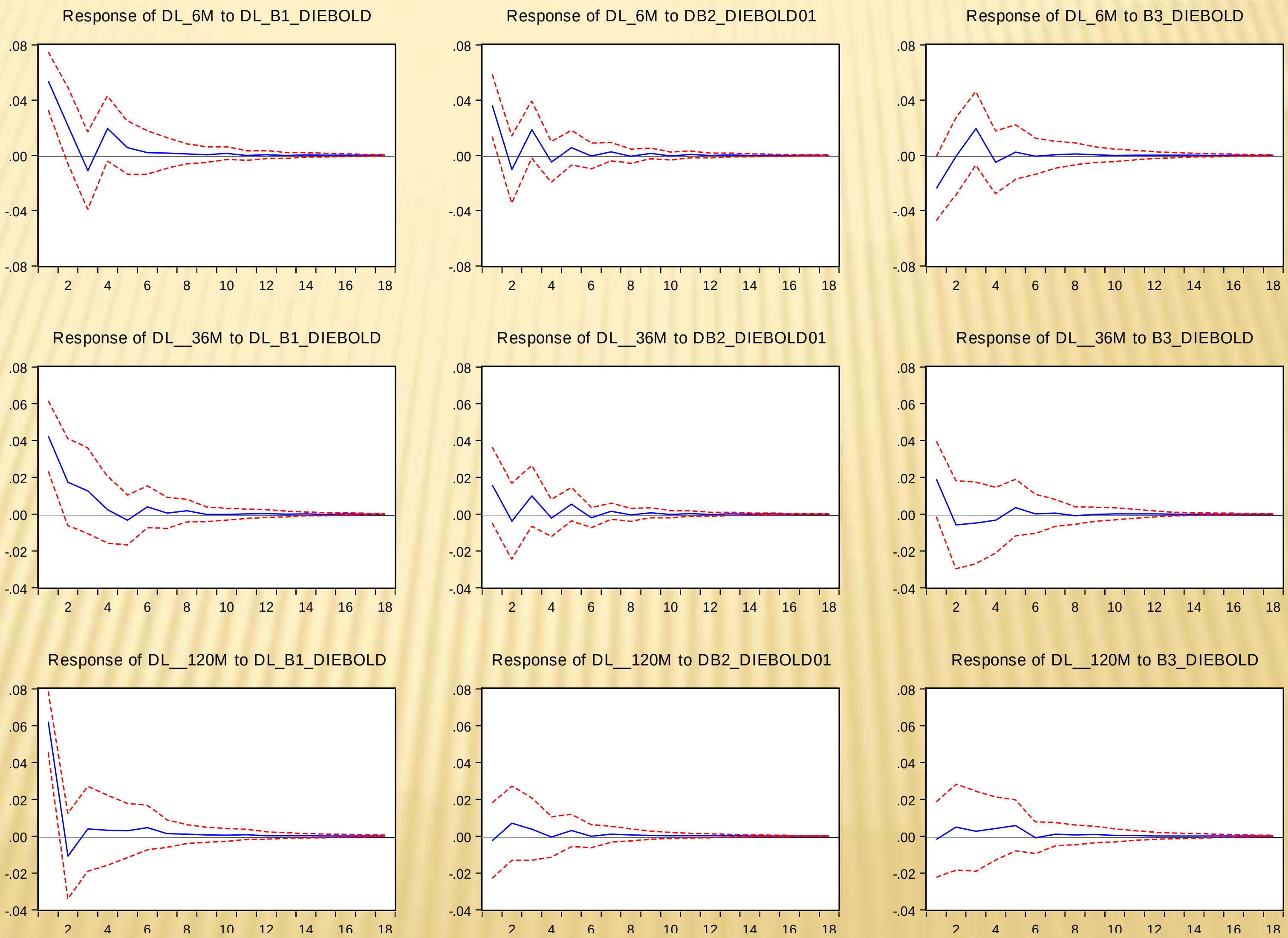


INTERCATION BETWEEN YIELD CURVE AND Latent Factors U-VAR (1)

6M

36M

120m



INTERCATION BETWEEN YIELD CURVE AND LATENT FACTORS

• ***Level (β_1)*** *=> A shock in B1 theoretically is associated with an upward shift of the curve*. A shock in **β_1** increase the long rate by 6bps and less than 6bps the medium and short rate.

• **Slope (β_2)** => A shock in **β_2** is associated with an inversion of the curve; thus, the short and medium side of the curve is shifting up. *10Y is declining but it is statistically insignificant.* This anomaly (deviation by the theory could be explained by:
-> *liquidity issue and sample feature:* inverted curve in the first two years of the sample exactly when the liquidity for 10y was poor. (10y barely started to be trade in 2012 even today the liquidity is very poor)
-> relatively new inflation targeting regime, inflation expectation is not well anchored, so 10Y is not reacting;

• ***Curvature (β_3)*** *=> One standard deviation shock to the curvature is associated with a hump-shaped yield curve again is a low statistical effect for long side.*

ROMANIA IN THE SAMPLE FIT /NELSON SIEGLE MODEL VS. RW (I)

A. Nelson-Siegel Model vs. "RW"

I. I assess **<u>fitting performance</u>** of the Nelson-Siegel models by dividing the full data sample into the initial estimation period 2M2007-3M201 (44 observations) and the fitting period **4M2011-2M2012;** maximum forecast horizon is: h_{max}=12m. For each model and each horizon I considers RMSE, the best statistics is highlight in bold.

NELSON-SIEGLEMODEL					
FH	RMSE6M	RMSE12M	RMSE36M	RMSE60M	RMSE120M
h=1	0,51	**0,27**	**0,09**	0,14	0,08
h=2	0,83	0,59	0,24	0,18	0,12
h=3	1,09	0,58	0,43	0,26	0,24
h=4	2,13	1,36	0,52	0,54	0,45
h=5	1,26	1,01	0,42	0,43	0,34
h=6	1,37	0,96	0,35	**0,26**	**0,27**
h=7	0,97	1,05	0,47	0,46	0,47
h=8	1,27	1,04	1,07	0,53	0,56
h=9	1,50	1,44	0,90	0,86	0,81
h=10	2,32	1,78	1,17	1,14	0,95
h=11	1,73	2,52	1,70	1,59	1,48
h=12	2,69	2,90	2,23	2,13	1,68

Nelson - Siegle-RW					
FH	MODEL-6m	MODEL-12m	MODEL-36M	MODEL-60M	MODEL-120M
h=1	RW	NELSON-SIEGL	NELSON-SIEGLE	RW	RW
h=2	RW	RW	RW	RW	RW
h=3	RW	RW	RW	RW	RW
h=4	RW	RW	RW	RW	RW
h=5	RW	RW	RW	RW	RW
h=6	RW	RW	RW	NELSON-SIEGLE	NELSON-SIEGLE
h=7	RW	RW	RW	RW	RW
h=8	RW	RW	RW	RW	RW
h=9	RW	RW	RW	RW	RW
h=10	RW	RW	RW	RW	RW
h=11	RW	RW	RW	RW	RW
h=12	RW	RW	RW	RW	RW

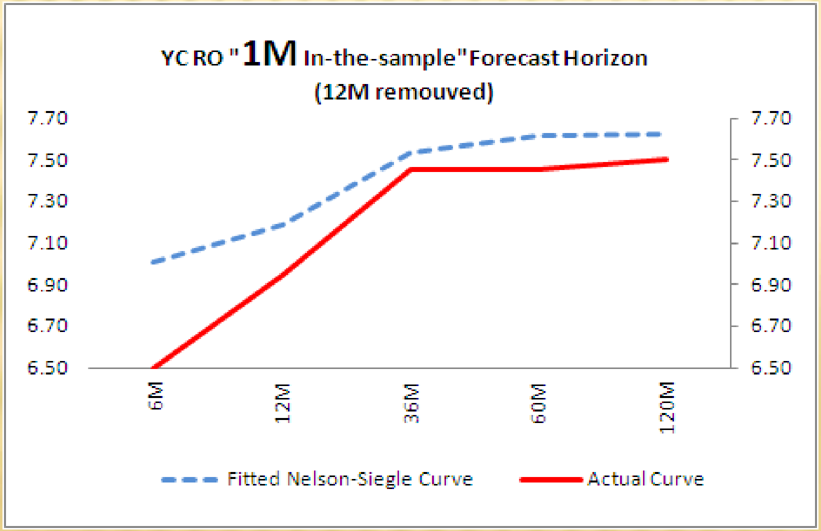
II. Is it the model able to capture the monetary policy shock? (I choose a downward trend of the interest rate) => **Sample 8M2007-2M2012**

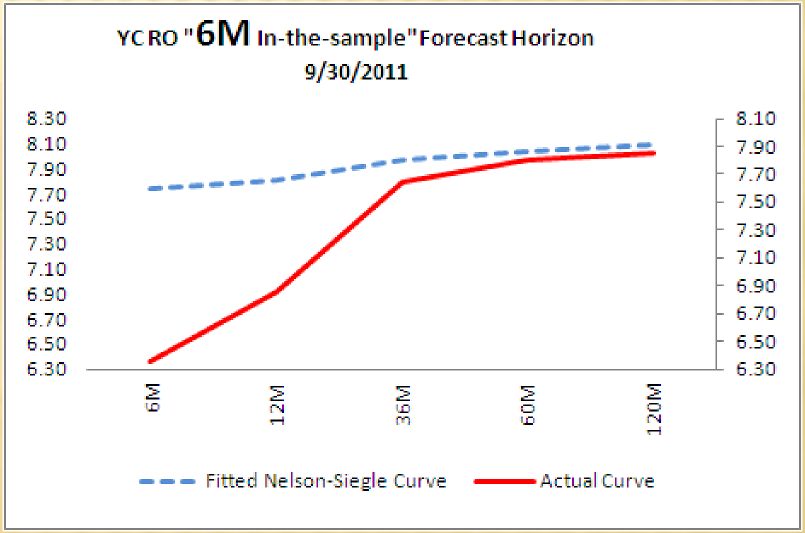
FH	RMSE6M	RMSE12M	RMSE36M	RMSE60M	RMSE120M
NELSON-SIEGLE	0,85	1,30	0,41	0,52	0,26
RANDOM WALK	**0,90**	**0,33**	**0,49**	**0,50**	**0,16**
h=1	NELSON-SIEGLE	RW	NELSON-SIEGLE	RW	RW

III. Is it the model able to capture **exogenous shocks**? (a upward trend in yields possibly due to turbulence in international market) => **Sample 8M2007-4M2012**

FH	RMSE6M	RMSE12M	RMSE36M	RMSE60M	RMSE120M
NELSON-SIEGLE	0,45	0,50	0,49	0,30	0,21
RANDOM WALK	0,52	0,77	0,14	0,25	0,24
h=1	NELSON-SIEGLE	NELSON-SIEGLE	RW	RW	NELSON-SIEGLE

1M, 6M Horizon "In sample Fit" Nelson-Siegel





ROMANIA “IN THE SAMPLE” FIT “NELSON SIEGLE” MODEL VS. "Direct regression on three AR(1) principal components”

B. Nelson-Siegel Model vs. Direct Regression on AR(1) PCA

- PCA analyses on the full data of yields, identifying unobs. Factors**; (L_t; S_t, C_t)**
- Univariate AR(1) model on unobs. Factors to produce h-step ahead forecast;

=> **Nelson-Siegel model outperform well “PCA model” with an increasing performance especially for medium and long term maturities.**

Eigenvalues: (Sum = 5, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	4.764415	4.608727	0.9529	4.764415	***0.9529***
2	0.155688	0.115688	0.0311	4.920103	***0.9840***
3	0.040000	0.015189	0.0080	4.960102	***0.9920***
4	0.024811	0.009724	0.0050	4.984913	0.9970
5	0.015087	---	0.0030	5.000000	1.0000

Eigenvectors (loadings):

Variable	PC 1	PC 2	PC 3	PC 4	PC 5
_6M	**0.446069**	**-0.444918**	**0.640883**	0.434889	0.056667
_12M	**0.448548**	**-0.312709**	**-0.763550**	0.335754	0.072656
_36M	**0.453831**	**-0.110246**	**0.046780**	-0.714778	0.518447
_60M	**0.455011**	**0.066650**	**0.020278**	-0.320531	-0.827871
_120M	**0.432238**	**0.829255**	**0.060509**	0.290677	0.193266

NELSON-SIEGLE

FH	RMSE6M	RMSE12M	RMSE36M	RMSE60M	RMSE120M
h=1	0,51	**0,25**	**0,08**	**0,17**	**0,12**
h=2	0,86	0,60	**0,25**	**0,21**	**0,16**
h=3	1,13	**0,60**	**0,45**	**0,28**	**0,27**
h=4	2,17	1,38	**0,53**	**0,55**	**0,47**
h=5	1,29	**1,02**	**0,41**	**0,43**	**0,34**
h=6	**1,39**	0,96	**0,32**	**0,24**	**0,24**

Nelson-Siegle - PCA AR(1)

FH	MODEL-6m	MODEL-12m	MODEL-36M	MODEL-60M	MODEL-120M
h=1	PCA	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE
h=2	PCA	PCA	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE
h=3	PCA	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE
h=4	PCA	PCA	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE
h=5	PCA	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE
h=6	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE	NELSON-SIEGLE

ROMANIA Models Comparison Remarks

I. *In line with the expectation, the model is performing enough well considering the inception phase of a yield curve construction.*

- The Nelson Siegel model proves to work better than is competitor RW for short horizon forecast. (1MH) and especially for short side and medium side of the curve (12m and 36M) but the pricing errors are large (>20bps).
- Moreover, the model could be used during the period which is characterized by a substantial amount of predictability, when the interest rates are fairly stable (6mH)
- As the forecast horizon increases the fitting is poor.

II. *Central Bank (NBR) cut the policy rate by a cumulative 100bps during November 2011-March 2012)*

• *The model was able to fit the only short side of the curve (6m); 12M is not fitted explained maybe by some portfolio interest or bonds market performance.*
• For long side (60M) and (120M), I explain the large deviation Actual/Fitted curve by shifted down in a parallel fashion (avg. 120bp for all maturities) of the curve, contrary with Estella and Mishkin study (1998) who conclude that monetary policy shocks primary affect short rate with a diminishing effect for long rate.

III. Spike in local bonds yield due to European market turmoil (Greek election, European debts crises etc).
• *NSM by far is beating* RW *especially on the short side of the curve and this time, even long side.*

FRANCE "IN THE SAMPLE" FIT NELSON SIEGLE MODEL VS. RW

Nelson-Siegle RMSE													
FH	RMSE3M	RMSE6M	RMSE9M	RMSE12M	RMSE24M	RMSE36M	RMSE48M	RMSE60M	RMSE72M	RMSE84M	RMSE96M	RMSE108M	RMSE120M
h=1	0,6715	0,3843	0,4852	18,3645	0,4153	0,2709	0,2011	**0,0938**	0,0910	**0,0123**	0,0702	0,0960	0,1209
h=2	0,6746	0,3526	40,7430	0,2095	**0,4334**	**0,0085**	**0,0976**	**0,1419**	**0,2026**	0,2481	0,2868	0,2894	0,3079
h=3	0,7218	0,4266	0,4103	**0,2427**	**0,3371**	**0,1428**	**0,1785**	**0,5731**	0,2054	0,2559	0,2742	0,2961	0,2076
h=4	0,7575	0,1333	0,2370	**0,5191**	**1,2473**	**0,5054**	**0,5933**	**0,9200**	0,6180	0,6304	0,6203	0,5977	0,4760
h=5	0,7885	**0,2931**	0,1950	**0,3769**	**0,9688**	**0,8625**	**0,9242**	**1,0964**	1,0475	1,0164	0,9755	0,9305	0,8237
h=6	0,8431	**0,5400**	**0,4934**	**0,5245**	1,0413	1,0084	1,1013	0,8377	1,1589	1,1783	1,1428	1,1130	1,1263
h=7	0,0182	0,4402	**0,4674**	**1,1339**	1,1717	0,8845	0,8954	0,6346	0,7822	0,7237	0,6867	0,6296	0,6298
h=8	0,0555	0,7625	0,5879	0,9591	1,2187	0,6641	0,6920	1,0762	0,5296	0,4256	0,3494	0,3222	0,3491
h=9	1,1345	1,1820	1,0775	1,2552	1,5684	1,1502	1,1583	1,1141	0,9198	0,7953	0,7177	0,6252	0,6032
h=10	0,9668	1,0120	1,0629	1,0788	1,2835	1,4057	1,3231	1,2445	1,0805	0,9618	0,8522	0,7659	0,7198
h=11	1,0977	1,1240	1,1877	1,2734	1,3491	1,4216	1,3742	1,2916	1,1921	1,0633	0,9430	0,8627	0,7977
h=12	1,1408	1,2469	1,3028	1,3736	1,4724	1,5649	1,4968	1,4387	1,2950	1,1761	1,0488	0,9627	0,9203

I run the model for France where 13 maturities were available and a larger sample (2M2002-3M2011), testing 1M-12M horizon forecast; I fix **λt** = **0,0597** for **T=30M**; finally reaching the following concluding remarks:

1. The longer is the forecasted horizon, a part of the short side of the YC (6m-12M) is better fitted by NS model vs. RW.

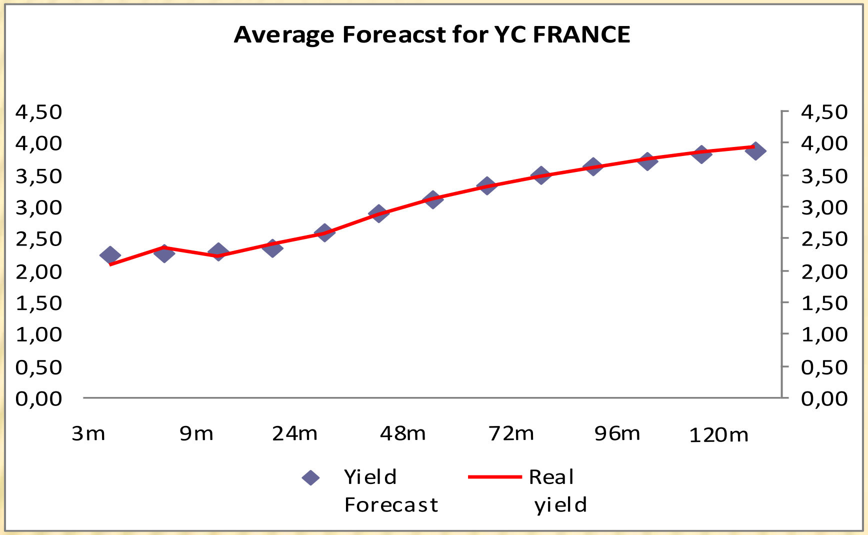
2. The number of maturities fitted well by NSM increase once the forecast horizon increases;(2MH-5MH).

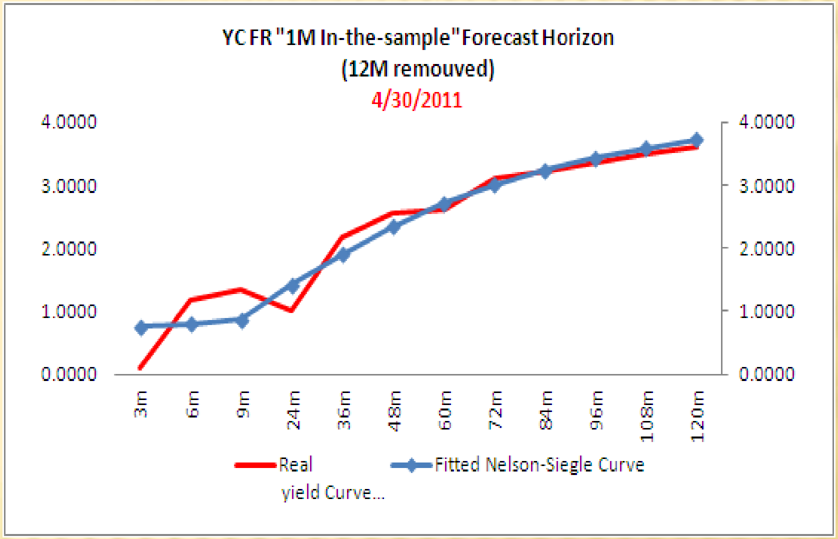
3. The fitting for the entire YC is poor for a horizon > 7M against the Diebold and Li (2006) findings for US bonds market.

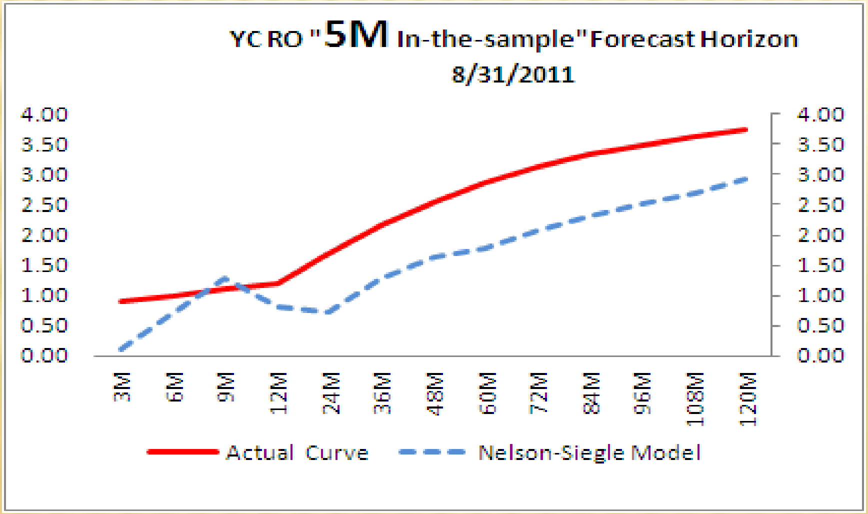
4. For a very close FH (1MH, 2MH) the pricing errors are in a range of 1bps-9bps. As the FH increase, the pricing errors increase, the largest errors corresponding to medium side of the curve.

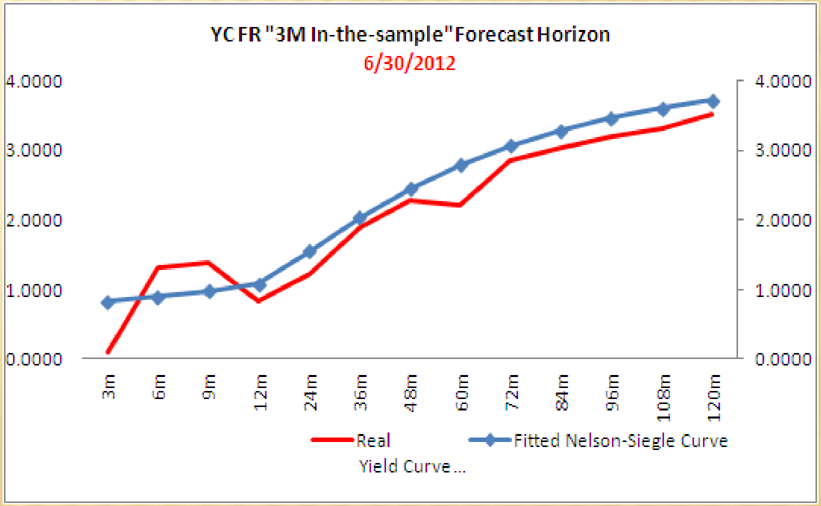
1M, 3M, 5M, Horizon “In the sample Fit” by NSM

Actual (data based) and Fitted Curve (model Based) Average Curve





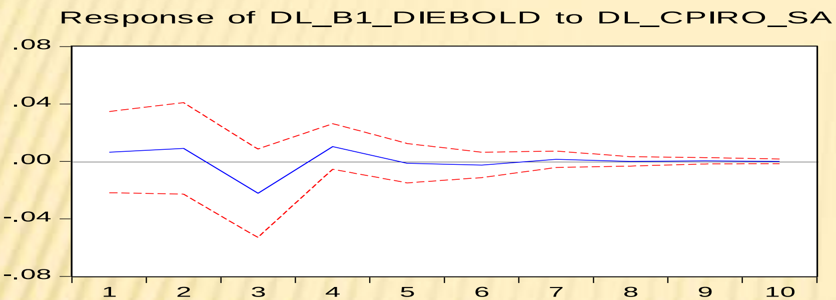


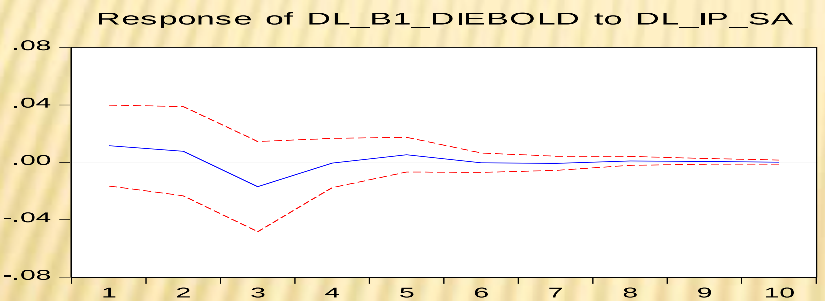


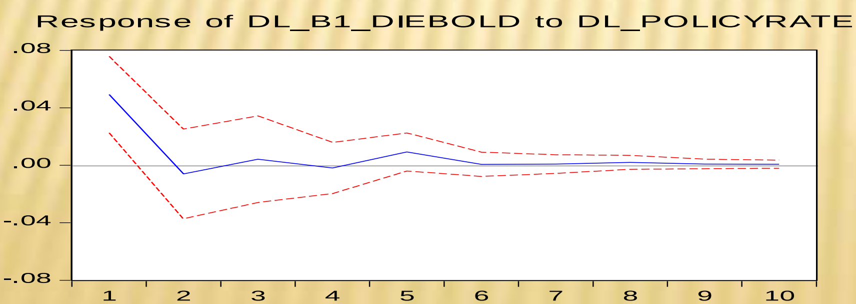
INTERCATION BETWEEN Latent Factors of the YC AND MACROECONOMY
U-VAR(3) with exogenous variables – IRF$_s$

RESPONSE OF B1 (LEVEL) TO

INFLATION SHOCK, IP SHOCKS, POLICY SHOCKS

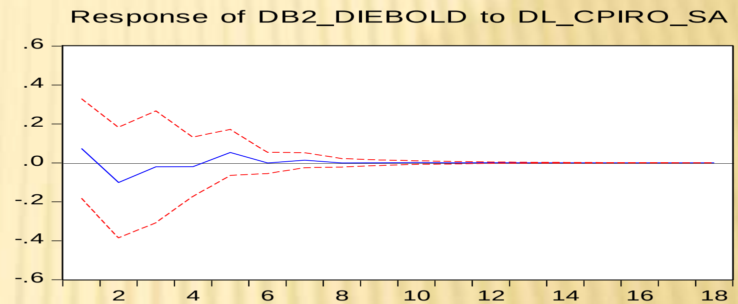


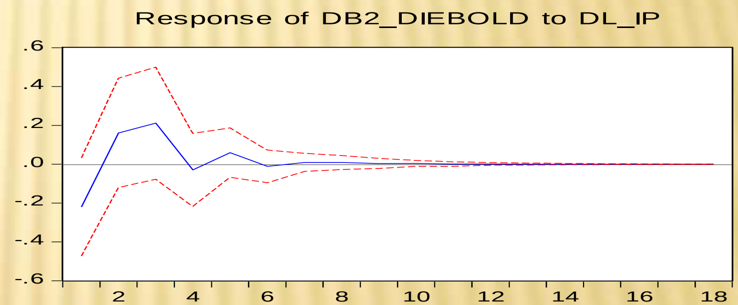


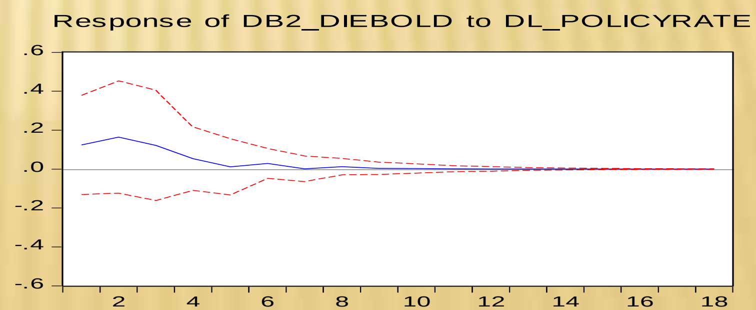


RESPONSE OF B2 SLOPE TO A

INFLATION SHOCK, IP, AND MONETARY POLICY SHOCKS;







INTERCATION BETWEEN YIELD CURVE AND MACROECONOMY – G-VAR(3)

β_1- Level

In Romania a shock to actual inflation (**CPI**), appear to give a short run boost to the **β_1** and moreover is statistically insignificant, denoting that 10Y yield is not bearing the economically significance; this could be explained by the relatively new and unreliable targeting inflation regime;

A monetary policy shock shift the level up by 40bps and die off after 2 periods denoting that the tightening measures represent a surprise for market players due to the fact that NBR is worry about inflation pressure; the result contradicts Estella and Mishkin study (1998) *who conclude that monetary policy shocks primary affect short rate with a diminishing effect for long rate.*

β_2 -Slope

An increase in the **NBR policy rate** push up **β_2** the slope will be less positively sloped; even if the IRFs is not significant, **ρ** (B_2 policy rate) =0,90 (p-value =0%) proving the strong connection between the Slope and monetary policy.

A one standard deviation shock to **CPI** is not significant at the level of **β_2** (it has a smoothed path). Theoretically, if the inflation is raising and the economy swells, the response the Central Bank increase the short rate and as a consequence the **β_2** rise.

A shock in **Industrial Production** initially put **β_2** down (as denoted by corr. coeff which is negative) but then after 2 periods remained above the baseline. Negative correlation between IP and **β_2** during the sample show that the slope is not connected with the of the economy maybe due to 10y rate not very liquid during the period. We expect from now a reverse in the correlation of the economy with the yield curve slope.

Concluding Remarks

Model Drawbacks:

• only 5 cross-sectionals data (currents maturities available on the local market) comparing with Diebold approach for US market (17 matt.);

Despite this: the Nelson Siegel model fit the curve and outperforms competitors models (RW, AR(1) on PCA);

=> only for very short forecast horizon; (h=1) which contradicts the findings of Diebold and Li (2006). findings

⇒ during periods with low yields volatility especially for long side of the curve;

⇒ unexpectedly, the empirical results validate Nelson-Siegel 3-factors model for ***short and medium side*** even during a strong easing cycle of monetary policy and also during period when exogenous shocks have weight on the curve;

For a developed bonds market (France) , the model outperforms RW in much more time and cross-section points, the main difference being that the pricing errors is in line with Diebold findings (max 9bps) but with some restriction: for long side and short horizon!

Dynamic interaction with macroeconominics:

➢ a short leave response of 10Y bond yield to a monetary policy shocks;

➢No synchronization between business cycle and slope of the curve **(β_2)**

Future research should consider macro factors to be included into Nelson Siegel-model using one-step approach, maybe more supportive to have an accurate conclusion related YC dynamics.

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