



**UNIVERSITY OF MACEDONIA
MASTER PROGRAM OF APPLIED ECONOMICS**


**THE YIELD CURVE AS A PREDICTOR OF GDP AND
UNEMPLOYMENT: THE CASE OF G7**

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**THESSALONIKI
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1. INTRODUCTION

- ▶ Researching the predictability of the Yield Curve for G7 Countries for GDP and Unemployment
 - ▶ Is it a valid forecasting tool in recent years?
 - ▶ How Unemployment and GDP respond on Yield curve's shocks
 - ▶ A multi-country analysis with the addition of Unemployment rate
- 

2. THEORETICAL BACKGROUND

Expectation Hypothesis

- Long-term interest rates are the average of expected future short-term rates.

Policy anticipation Hypothesis

- Affection of monetary policy changes
- Current monetary policy may shift both the yield curve and future output.

Liquidity preference theory

- Investors prefer to hold short-term bonds in place of long-term bonds
- Information of the risk premium

3. LITERATURE REVIEW

Estrella, A., & Hardouvelis, G. A. (1991).

- The term structure as a predictor of real economic activity. *The Journal of Finance*, 46(2), 555–576.

Bonser-Neal, C., & Morley, T. R. (1997).

- Does the yield spread predict real economic activity? A multicounty analysis. *Economic Review—Federal Reserve Bank of Kansas City*, 82(3), 37.

Haubrich, J. G., & Dombrosky, A. M. (1996).

- Predicting real growth using the yield curve. *Economic Review*, 32(1), 26–35.

Dong, M., & Xiao, S. X. (2019).

- Liquidity, monetary policy, and unemployment: a new monetarist approach. *International Economic Review*, 60(2), 1005–1025.

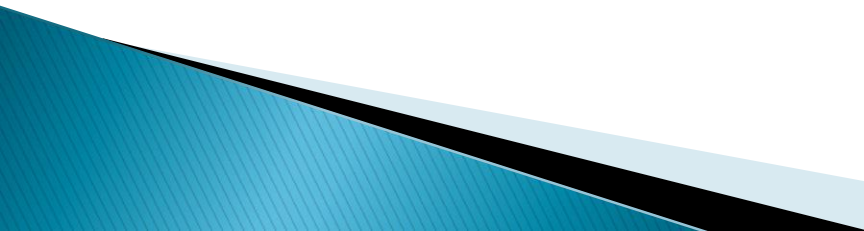
Cinquegrana, G., & Sarno, D. (2010). (De Gruyter Open),

- THE YIELD CURVE AND THE PREDICTION ON THE BUSINESS CYCLE: A VAR ANALYSIS FOR THE EUROPEAN UNION. *Theoretical & Practical Research in Economic Fields*

4. DATA AND METHODOLOGY



4.1 Choosing the Yield spread length

- ▶ Yield curve is the difference between interest rates on long-term and short-term security.
 - ▶ Securities that are actively traded
 - ▶ 10-year Treasury bond rate and the 3-month Treasury bill rate.(Estrella, A., & Hardouvelis, G. A. (1991).
 - ▶ In countries where these assets are not traded another alternative asset must be used
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4.2 Sample size

	CANADA	FRANCE	GERMANY	ITALY	JAPAN	U.K.	U.S.
Monthly	M01 1973 - M08 2020	M01 1983 - M08 2020	M01 1991 - M08 2020	M01 1991 - M08 2020	M04 1994 - M08 2020	M01 1973 - M06 2017	M01 1973 - M08 2020
Quarterly	Q01 1973 - Q3 2020	Q01 1983 - Q3 2020	Q01 1991 - Q3 2020	Q01 1991 - Q3 2020	Q02 1994 - Q3 2020	Q01 1973 - Q2 2017	Q01 1973 - Q3 2020

4.3 Forecasting Basis

$$y_t = C(1) + C(2)x_t + C(3)Z_t \quad \longrightarrow \quad \text{Simple Linear regression forecasting}$$

$$Y_s = C(1) + C(2)X_s + C(3)Z_s + C(4)y_{s-1} \quad \longrightarrow \quad \text{Dynamic forecasting with lagged dependent variables}$$

$$y_s = C(1) + C(2)X_{s+N} + C(3)Z_{s+N} + C(4)\check{y}_{s+K-1}$$

4.4 In-Sample and Out-of-Sample Forecasting

- Yield Spread
In-Sample



GDP growth_t or Unemployment rate_t = a + b spread_t

- Yield Spread
Out-of-Sample



GDP growth_t or Unemployment rate_t = a + b spread_t

•Lagged GDP growth
and Lagged
Unemployment rate

$$= a + b \text{ GDP growth}_{t-n} \text{ or } a + b \text{ Unemployment rate}_{t-n}$$

•Lagged GDP growth
and Lagged
Unemployment plus
the yield spread

$$a + b \text{ GDP growth}_{t-n} + c \text{ spread}_t \text{ or } a + b \text{ Unemployment rate}_{t-n} + \text{spread}_t$$

•Industrial
Production as a
leading indicator

$$\text{GDP growth}_t \text{ or Unemployment rate}_t = a + b \text{ Industrial production}_t$$

4.5 Forecast Evaluation

Root Mean Squared Error

The standard deviation of the residuals

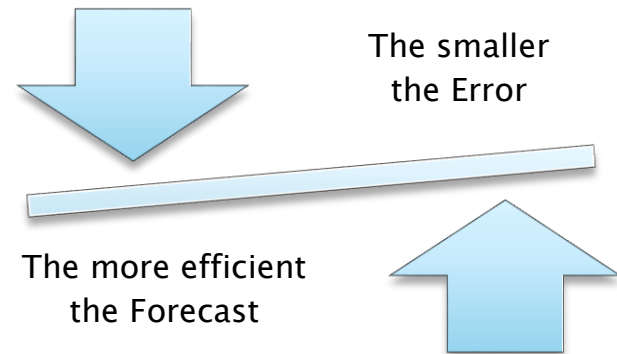
A measure of how far from the regression line are the data points

How spread out the residuals are.

4.5.1 Root Mean Squared Error equations

$$a) \sqrt{\sum_{i=1}^n \frac{(\hat{y}_i - y_i)^2}{n}}$$

$$b) \sum \frac{(y_t - \hat{y}_t)^2}{h} = \left\{ \left(\sum \frac{\hat{y}_t}{h} \right) - \bar{y} \right\}^2 + (s_y - s_{\hat{y}})^2 + 2(1-r)s_y s_{\hat{y}}$$



4.6 Vector Autoregressive Model

4.6.1 Unit Root Tests

- ▶ $y_t = \tau D_t + z_t$
 $\tau D_t = \kappa + \delta_t$
 $z_t = \phi z_{t-1} + \epsilon_t, \epsilon_t \sim WN(0, \sigma^2)$


If $\phi < 1$ then $y_t \Rightarrow I(0)$

If $\phi = 1$ then $y_t \Rightarrow I(1)$

$z_t, \phi(z) = (1 - \phi z) = 0$, has root equal to unity

4.6.4 Johansen Cointegration Test

$$\begin{matrix} \triangleright & y_t & = & \beta_1 & y_{t-1} & + & \beta_2 & y_{t-2} & + \dots + & \beta_k & y_{t-k} & + & u_t \\ & g \times 1 & & g \times g & g \times 1 & & g \times g & g \times 1 & & g \times g & g \times 1 & & g \times 1 \\ & g \times 1 & & & & & & & & & & & \end{matrix}$$


$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \dots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t$$

Cointegrated  VAR restricted model(VECM)

Not Cointegrated  Standard VAR model

4.7 Impulse responses

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + Cx_t + \epsilon_t$$



VAR process

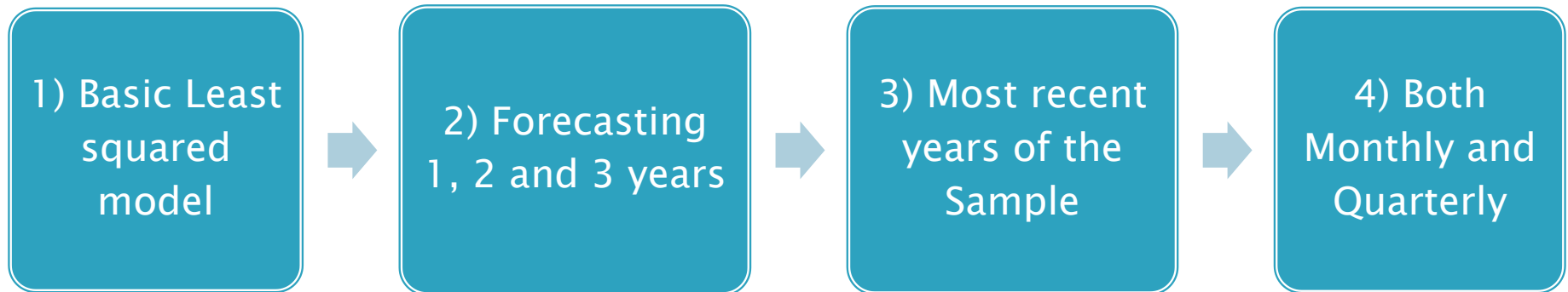
- Describe the evolution of a model's variables in reaction to a shock in one or more variables
- Trace the transmission of a single shock within noisy system of equations

Impulse Response Function:

$$\varphi_i = \sum_{j=1}^i \varphi_{i-j} A_j, \quad i = 1, 2, \dots, n$$

5. RESULTS

5.1 Yield Spread and Leading Indicator In-Sample and Out-Of-Sample



Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for GDP growth with yield spread monthly frequency

GDP Growth	Yield Spread : In-Sample		
	1 year	2 years	3 Years
<u>Canada</u>	0,26	0,23	0,55
<u>France</u>	0,27	0,22	0,3
<u>Germany</u>	0,55	0,44	0,59
<u>Italy</u>	0,34	0,25	1,79
<u>Japan</u>	0,58	0,58	0,8
<u>UK</u>	0,07	0,11	0,12
<u>US</u>	0,26	0,21	0,8

Yield Spread : Out-Of-Sample		
1 Year	2 years	3 Years
0,21	0,22	1,06
0,24	0,15	1,98
0,54	0,44	0,6
0,28	0,21	1,8
0,49	0,5	0,8
0,08	0,11	0,12
0,23	0,18	0,81

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate ,monthly frequency

Unemployment Rate	In-Sample				Out-of-sample		
	1st Year	2nd year	3rd Year		1st Year	2nd year	3rd Year
Canada	1,85	1,97	1,99		1,95	2,07	2,1
France	0,54	0,75	1,05		0,66	0,87	1,17
Germany	3,28	3,47	3,46		3,72	3,91	3,93
Italy	1,33	1,05	0,87		1,43	1,15	0,95
Japan	0,87	1,03	1,09		1,54	1,69	1,78
UK	1,13	1,53	1,83		0,35	1,02	1,44
US	1,79	1,84	1,78		1,87	1,93	1,88

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for GDP growth, quarterly frequency, yield spread equation

GDP Growth	In-Sample			Out-of-sample		
	1 year	2 years	3 years	1 year	2 year	3 years
Canada	0,26	0,3	3.36	0,24	0,2	4,32
France	0,56	0,54	2,89	0,39	0,46	2,9
Germany	0,42	0,71	4,31	0,47	0,48	3,97
Italy	0,28	0,22	3,97	0,26	0,2	3,98
Japan	0,49	0,58	2,32	0,42	0,53	2,36
UK	0,09	0,15	0,16	0,09	0,14	0.16
US	0,21	0,2	2.71	0,19	0,22	2,74

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, yield spread equation

Unemployment Rate	In-Sample			Out-of-sample		
	1 year	2 years	3 years	1 year	2 years	3 years
Canada	1,38	1,42	2,05	1,41	1,45	2,07
France	0,62	0,87	1,3	0,74	0,96	1,43
Germany	3,4	3,46	3,3	3,87	3,96	3,83
Italy	1,22	0,93	0,86	1,29	1	0,9
Japan	0,92	1,05	1,07	1,6	1,7	1,74
UK	0,68	1,1	2,38	0,33	0,64	2,32
US	1,6	1,53	2,58	1,95	1,98	2,73

5.1.1 Lagged GDP growth and Unemployment rate

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, Lagged GDP and Lagged GDP plus spread, monthly frequency

	Lagged GDP growth				Lagged GDP plus spread		
Canada	0,28	0,26	0,6		0,26	0,23	1,04
France	0,34	0,54	1.99		0,42	0,27	1,95
Germany	0,56	0,45	0,61		0,6	0,48	0,57
Italy	0,18	0,23	1,78		0,37	0,28	1,19
Japan	0,37	0,42	0,83		0,59	0,57	0,8
UK	0,10	0.12	0.13		0,07	0,11	0,12
US	0,21	0,18	0,42		0,25	0,21	0,38

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, Lagged Unemployment Rate and Lagged Unemployment plus spread, monthly frequency

	Lagged Unemployment Rate				Lagged Unemployment Rate plus spread		
	1	2	3		1	2	3
Canada	1	0,92	1,6		0,86	1,11	1,25
France	0,65	0,83	1,09		0,66	0,84	1,09
Germany	0,48	0,68	0,84		0,5	0,72	0,87
Italy	0,33	0,55	0,87		0,4	0,83	1,18
Japan	0,47	0,66	0,78		0,32	0,44	0,48
Uk	1,48	1,88	2,18		1,61	2,03	2,33
Us	1,01	1,38	1,67		1,05	1,36	1,52

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, Lagged GDP and Lagged GDP plus spread, quarterly frequency

	Lagged GDP				Lagged GDP plus spread		
Canada	0,3	0,34	3.43		0,32	0,32	3,39
France	0,56	0,54	2,89		0,42	0,71	4,31
Germany	0,6	0,5	2,89		0,63	0,53	2,81
Italy	0,18	0,23	2,74		0,39	0,3	1,59
Japan	0,33	0,47	2,41		0,47	0,57	2,34
UK	0,12	0.17	0.16		0,12	0,17	0,16
US	0,21	0,19	2,72		0,24	0,21	2,68

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, Lagged Unemployment Rate and Lagged Unemployment rate plus spread, quarterly frequency

	Lagged Unemployment Rate				Lagged Unemployment Rate plus spread		
Canada	0,96	1,15	1,25		0,97	1,15	1,21
France	0,68	0,87	1,19		0,69	0,88	1,18
Germany	0,56	0,75	0,86		0,6	0,79	0,88
Italy	0,31	0,55	0,96		0,43	0,86	1,28
Japan	0,52	0,65	0,71		0,35	0,41	0,42
UK	1,6	1,95	2,24		1,74	2,1	2,39
US	1,1	1,46	1,72		1,17	1,41	1,53

5.1.2 Leading Indicator – Industrial Production

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for GDP Growth with leading indicator: Industrial Production. monthly frequency

GDP Growth	In-Sample			Out-of-sample		
	1 year	2 year	3 year	1 year	2 year	3 year
<u>Canada</u>	0,33	0,28	1,05	0,24	0,2	1.08
<u>France</u>	0,56	0,54	2,01	0,39	0,23	2,9
<u>Germany</u>	0,42	0,38	1	0,41	0,38	1,03
<u>Italy</u>	0,56	0,44	1,7	0,37	0,27	1,79
<u>Japan</u>	0,39	0,43	0,8	0,36	0,42	0,85
<u>UK</u>	0,18	0,23	0,74	0,19	0,25	0,76
<u>US</u>	0,29	0,24	0,4	0,26	0,2	0,82

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate with leading indicator: Industrial Production, monthly frequency

Unemployment Rate	In-Sample			Out-of-sample		
	<u>1 year</u>	<u>2 year</u>	<u>3 year</u>	<u>1 year</u>	<u>2 year</u>	<u>3 year</u>
Canada	0,81	0,92	1,04	0,96	1,08	1,2
France	0,27	0,48	0,82	0,35	0,56	0,9
Germany	2,09	2,26	2,52	2,1	2,26	2,53
Italy	1,04	0,82	0,76	0,89	0,7	0,72
Japan	1,22	1,37	1,46	1,44	1,59	1,69
UK	1	1,37	1,6	1,16	1,53	1,8
US	1,2	1,35	1,49	1,4	1,56	1,7

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for GDP growth, quarterly frequency, leading indicator equation

GDP Growth	In-Sample			Out-of-sample		
	1 year	2 year	3 year	1 year	2 year	3 year
<u>Canada</u>	0,35	0,39	3,35	0,24	0,2	4,32
<u>France</u>	0,56	0,54	2,89	0,39	0,46	2,9
<u>Germany</u>	0,42	0,71	4,31	0,39	0.52	2.91
<u>Italy</u>	0,47	0,4	3,51	0,32	0,25	3,78
<u>Japan</u>	0,35	0,48	2,14	0,35	0,48	2,3
<u>UK</u>	0,08	0,12	0.17	0,08	0,16	0,17
<u>US</u>	0,28	0,23	2,7	0,26	0,22	2,71

Root Mean Squared Errors in the basis of 1,2 and 3 years forecasting for Unemployment Rate, quarterly frequency, leading indicator equation

Unemployment Rate	In-Sample				Out-of-sample		
	1 year	2 years	3 years		1 year	2 years	3 years
Canada	1,96	2,15	2,52		2,31	2,5	2,77
France	0,34	0,58	1,38		0,43	0,67	1,47
Germany	1,21	1,51	1,98		2,06	2,32	2,64
Italy	0,93	0,71	1,3		0,8	0,61	1,43
Japan	0,68	1,1	2,38		0,33	0,64	2,32
UK	1,17	1,52	1,78		1,33	1,68	1,94
US	1,31	1,44	2,47		1,48	1,62	2,55

5.2 VAR model – Impulse response

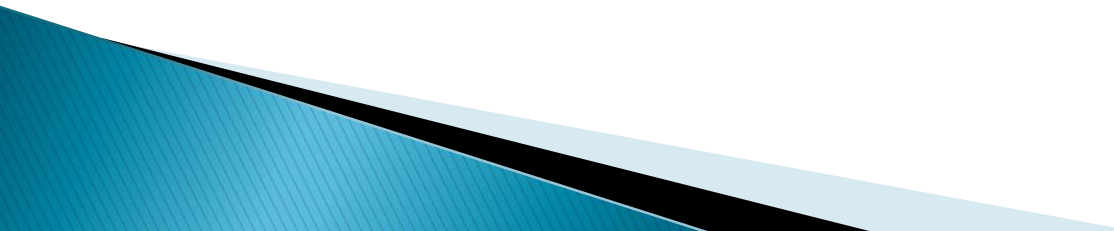
5.2.1 Lag length

AIC	Frequency	Number of lags for GDP growth model	Number of lags for Unemployment Rate model
Canada	Monthly	11	9
	quarterly	2	3
France	Monthly	12	9
	quarterly	3	3
Germany	Monthly	11	4
	quarterly	2	2
Italy	Monthly	11	12
	quarterly	3	3
Japan	Monthly	11	5
	quarterly	1	2
U.K.	Monthly	11	6
	quarterly	8	2
U.S.	Monthly	12	7
	quarterly	5	4

Function for Lag order:

$$LR = (T - m) \left\{ \log \left| \sum_{e, l-1} | - \left| \sum_{e, 1} | \right\} \sim \chi^2(k^2) \right.$$

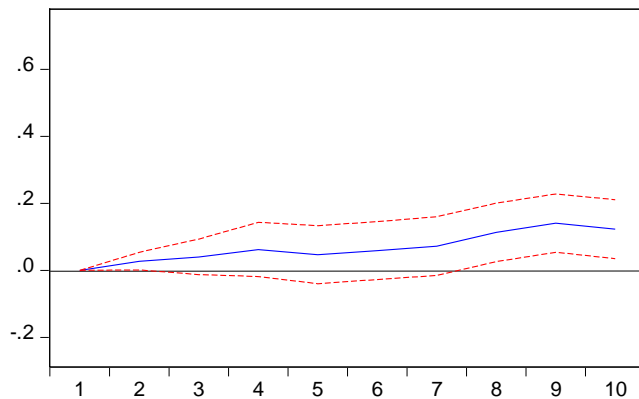
5.2.2 Unit roots and Johansen Cointegration test

- ▶ GDP growth and Yield Spread proved stationary and Unemployment Rate non stationary
 - ▶ No cointegration in any of the G7 countries, Standard VAR model
- 

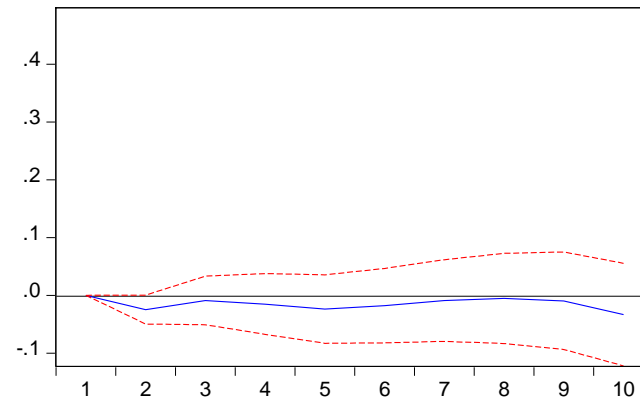
5.2.3 Impulse responses – monthly frequency

a) Canada

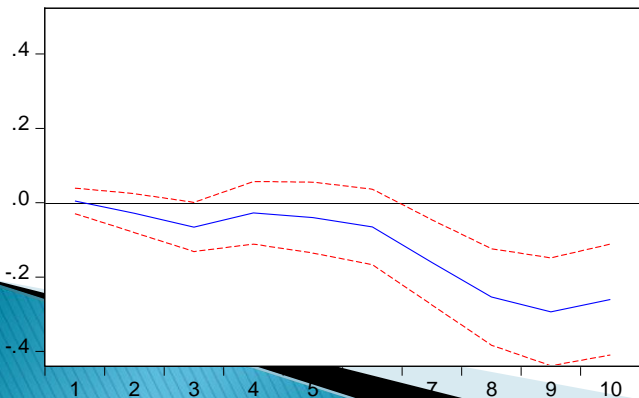
Response of GDP Growth to Yield Spread



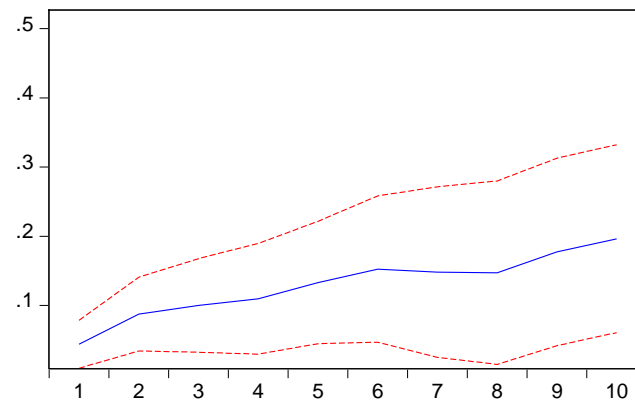
Response of Unemployment rate to Yield spread



Response of Yield Spread to GDP Growth

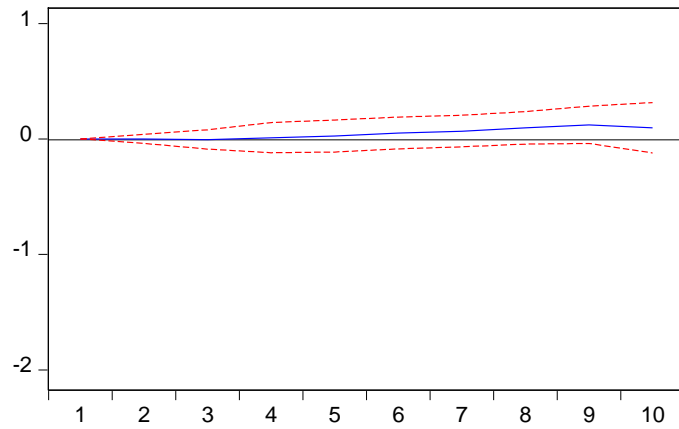


Response of Yield Spread to Unemployment rate

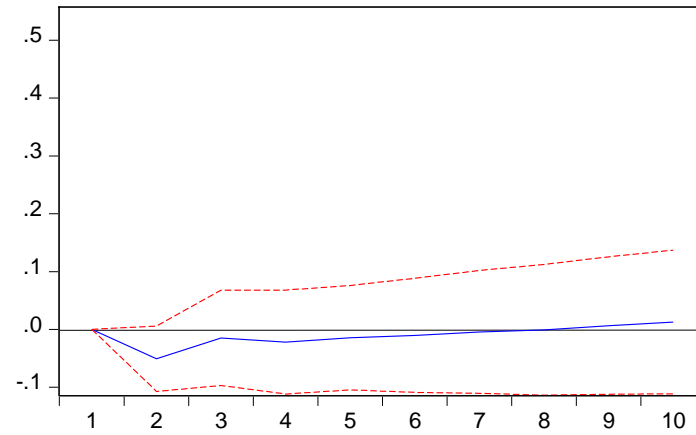


b) France

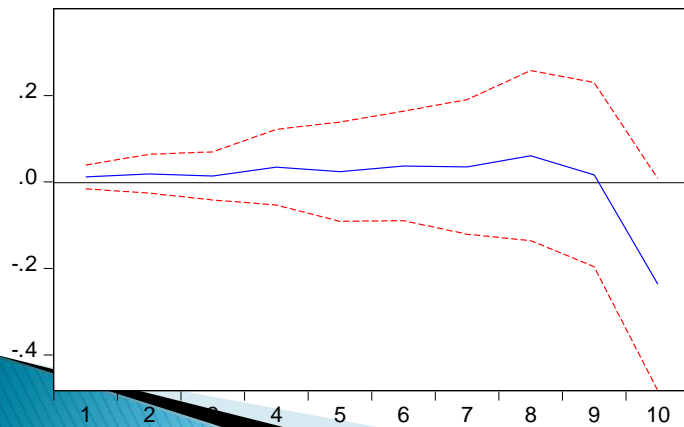
Response of GDP Growth to Yield Spread



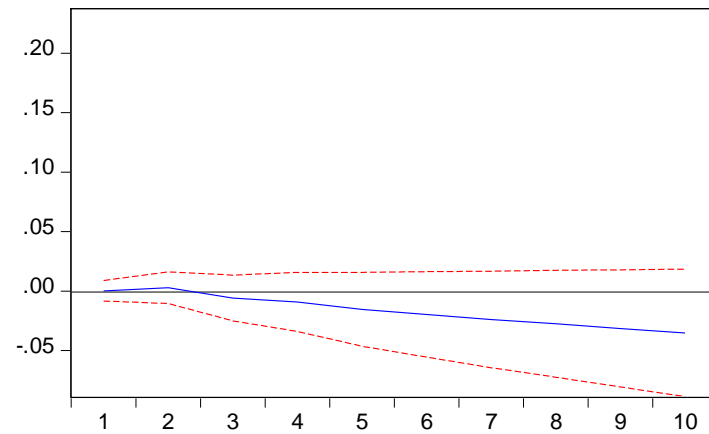
Response of Yield Spread to Unemployment Rate



Response of Yield Spread to GDP Growth

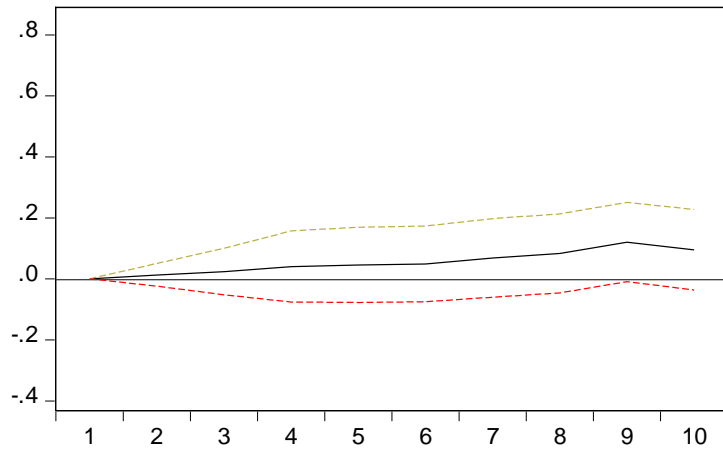


Response of Unemployment Rate to Yield Spread

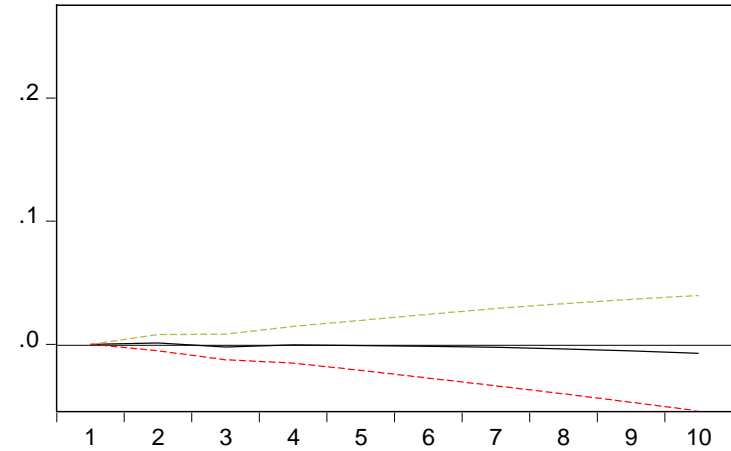


c) Germany

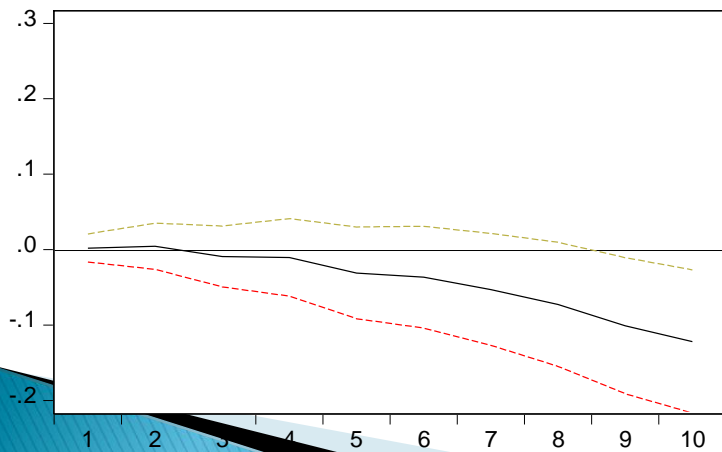
Response of GDP Growth to Yield Spread



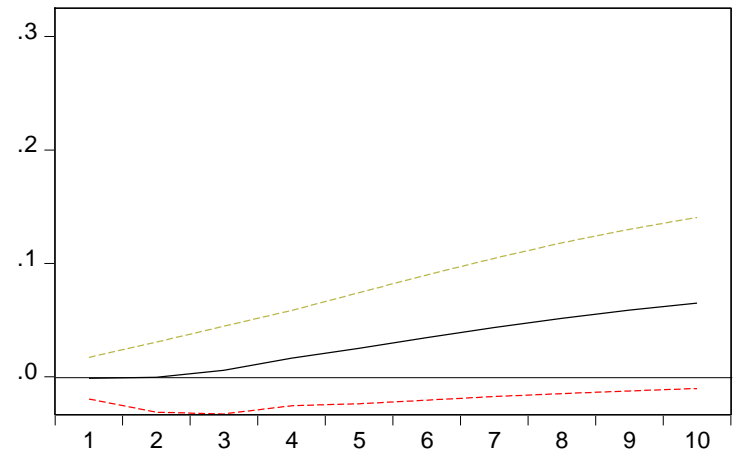
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

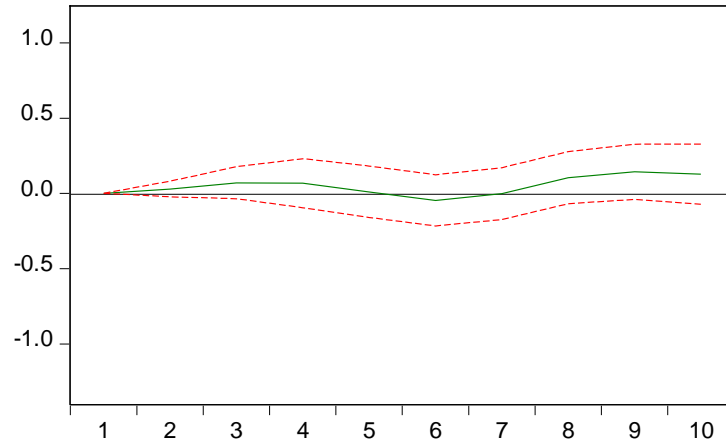


Response of Yield Spread to Unemployment rate

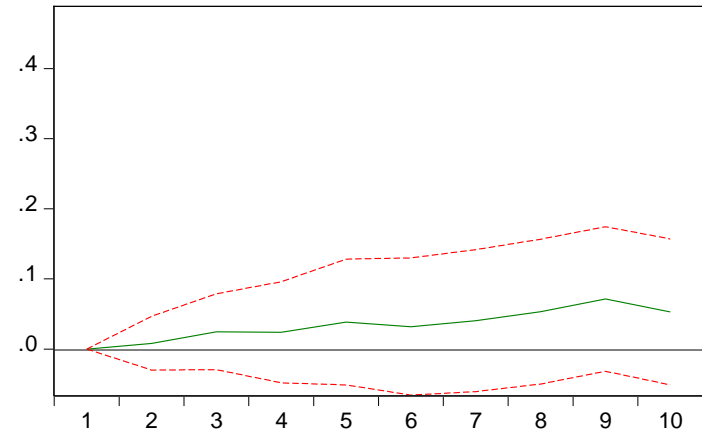


d) Italy

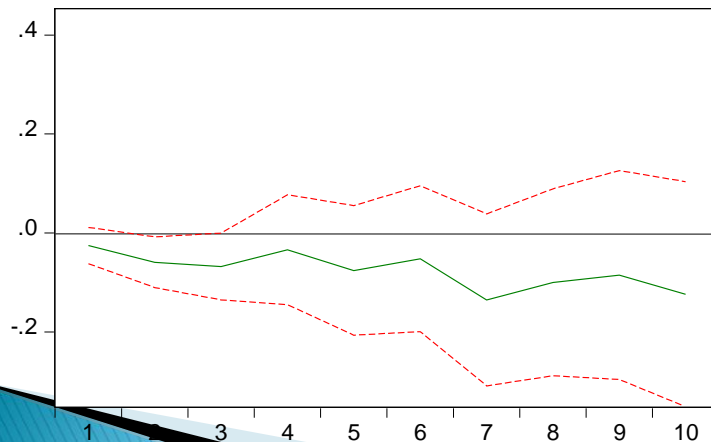
Response of GDP Growth to Yield Spread



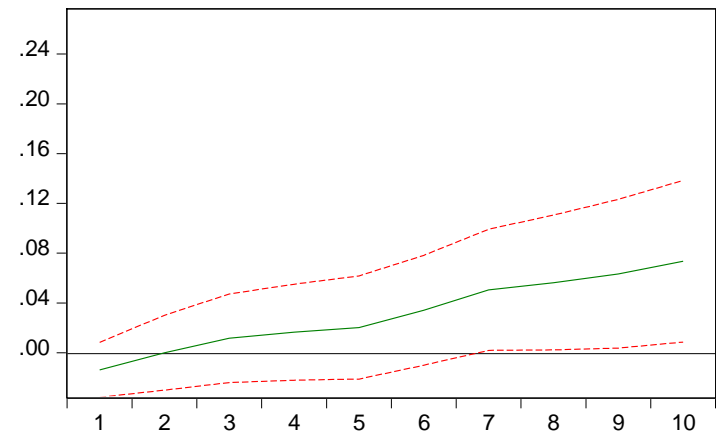
Response of Yield Spread to Unemployment rate



Response of Yield Spread to GDP Growth

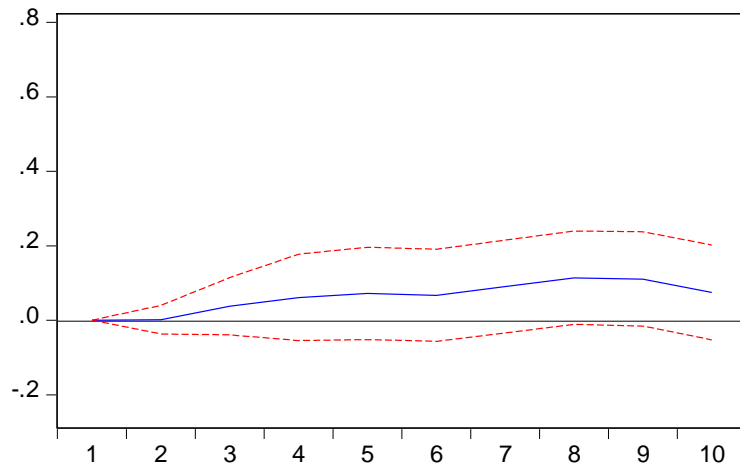


Response of Unemployment rate to Yield Spread

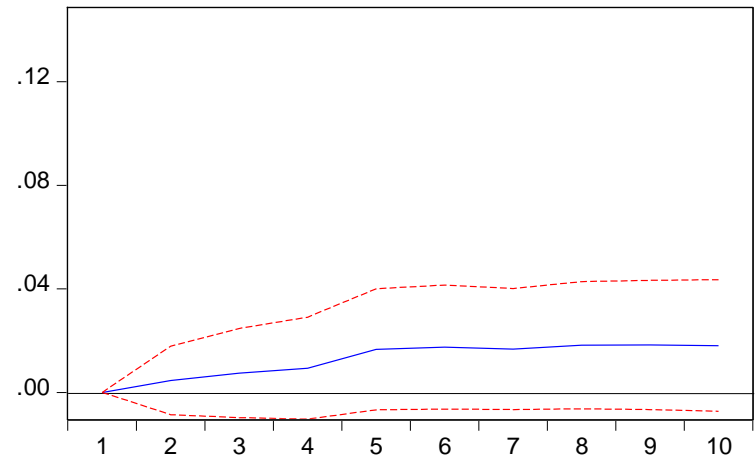


e) Japan

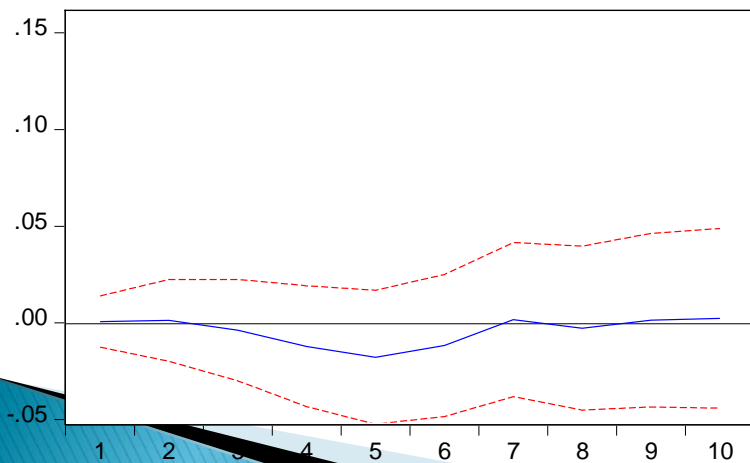
Response of GDP Growth to Yield Spread



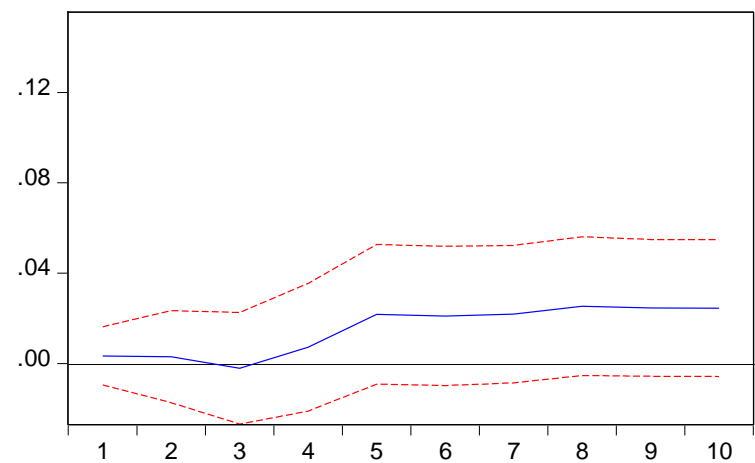
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

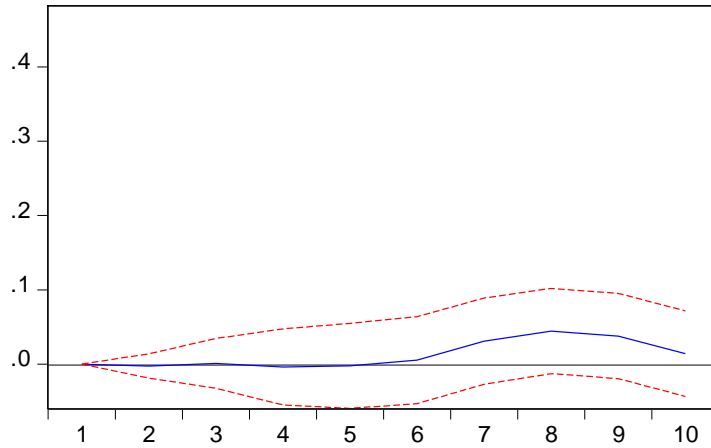


Response of Yield Spread to Unemployment rate

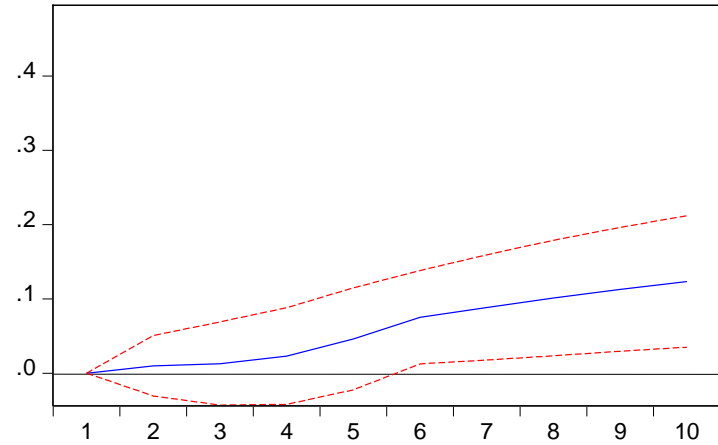


f) United Kingdom

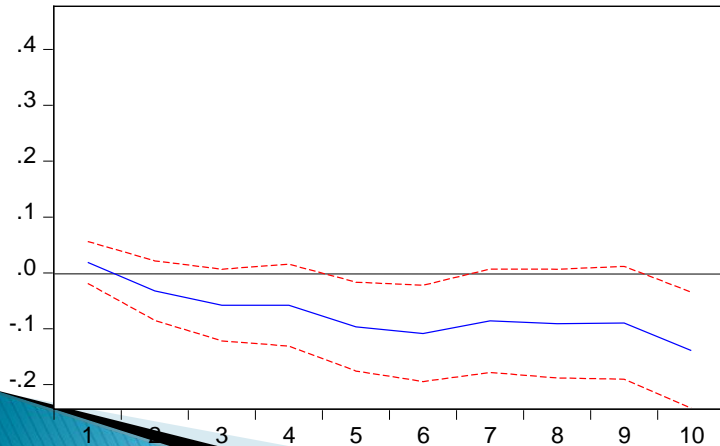
Response of GDP growth to Yield Spread



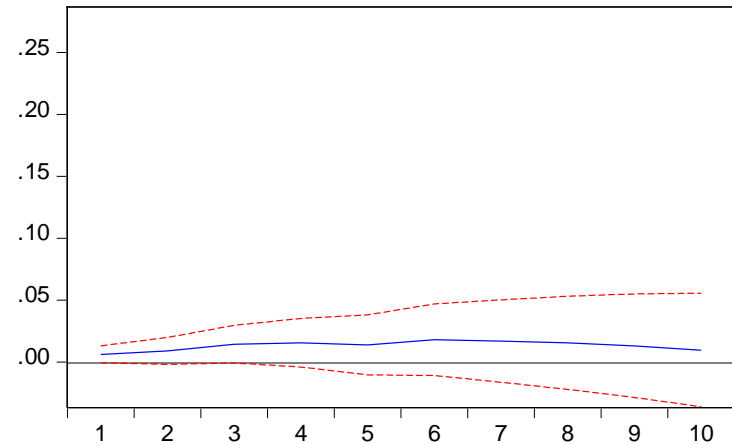
Response of Yield Spread to Unemployment rate



Response of Yield Spread to GDP growth

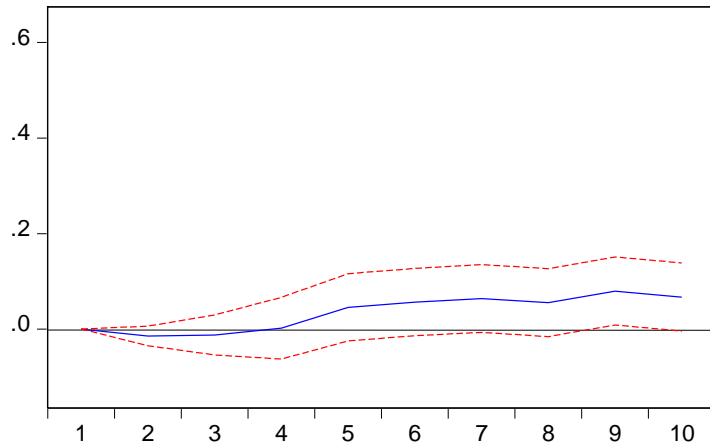


Response of Unemployment rate to Yield Spread

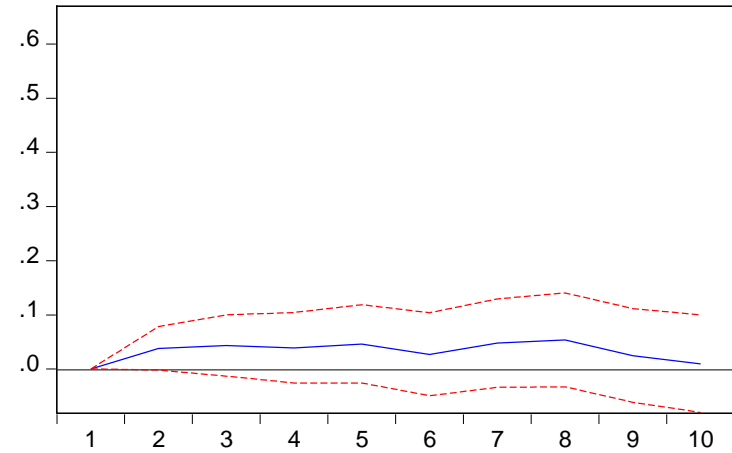


g) United States

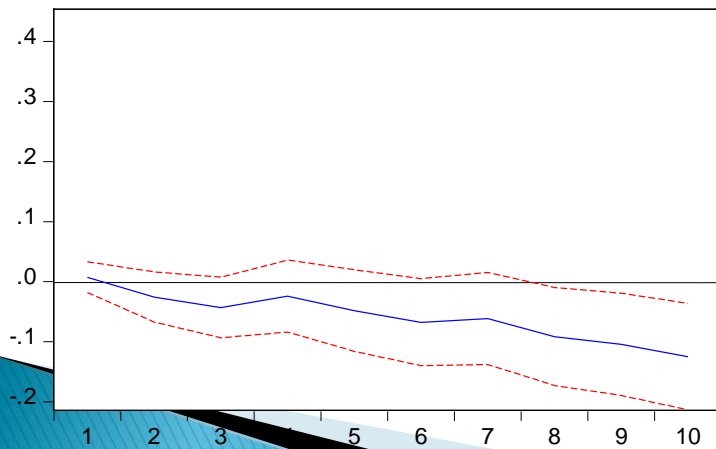
Response of GDP Growth to Yield Spread



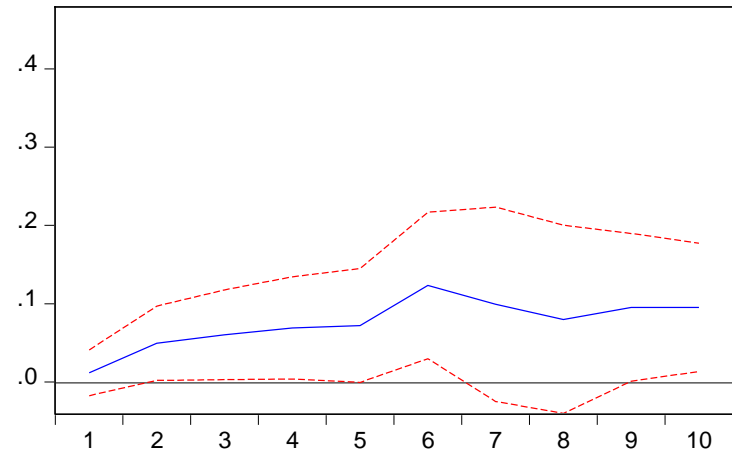
Response of Unemployment Rate to Yield Spread



Response of Yield Spread to GDP Growth



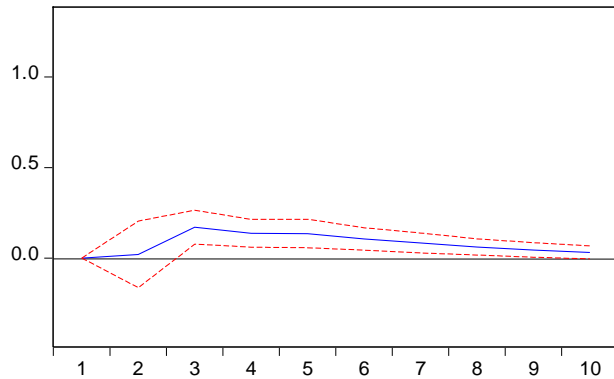
Response of Yield Spread to Unemployment Rate



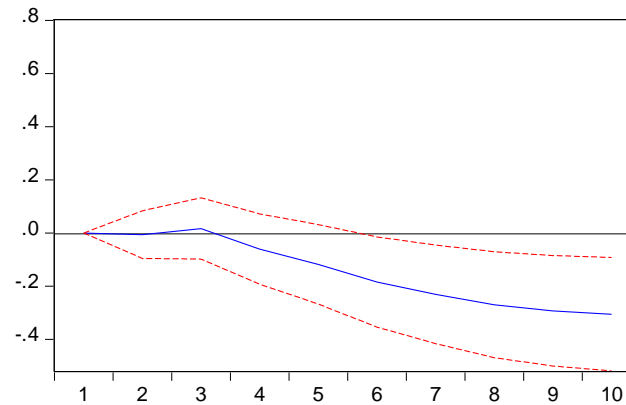
5.2.4 Impulse responses – quarterly frequency

a) Canada

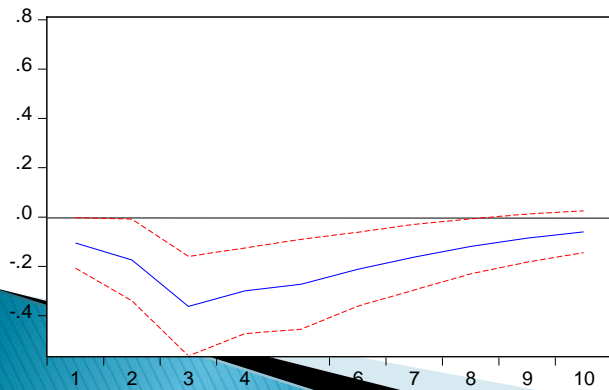
Response of GDP Growth to Yield Spread



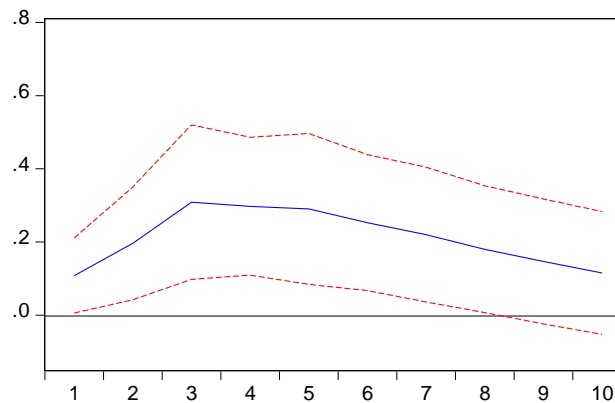
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

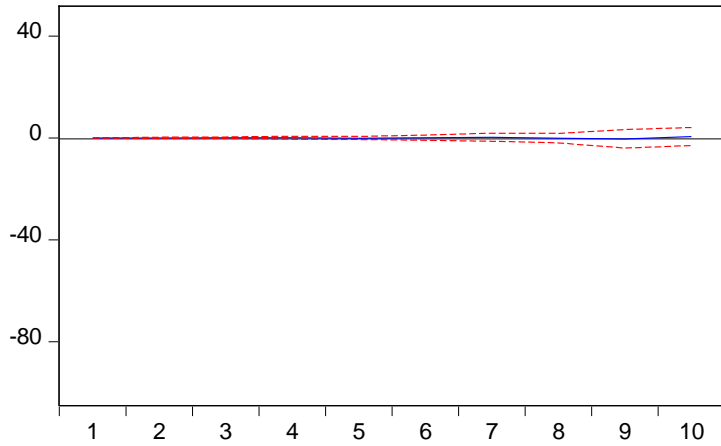


Response of Yield Spread to Unemployment rate

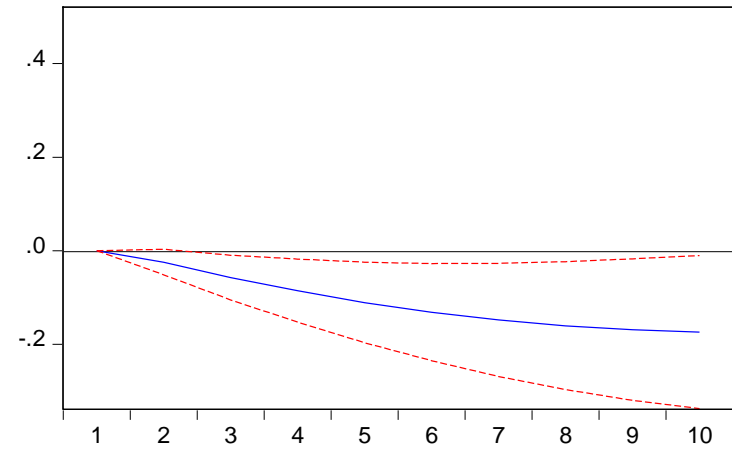


b) France

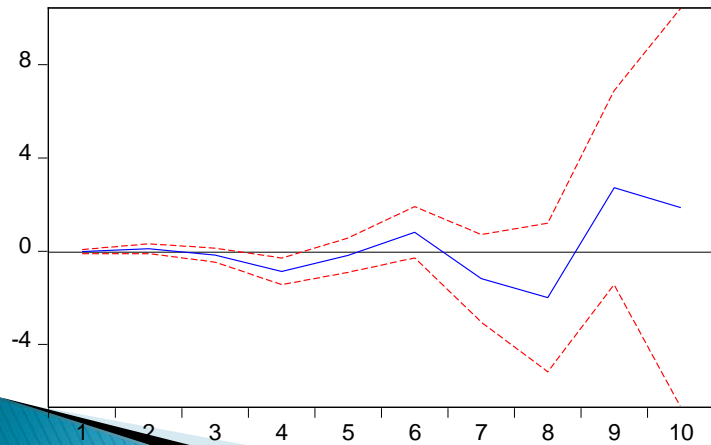
Response of GDP Growth to Yield Spread



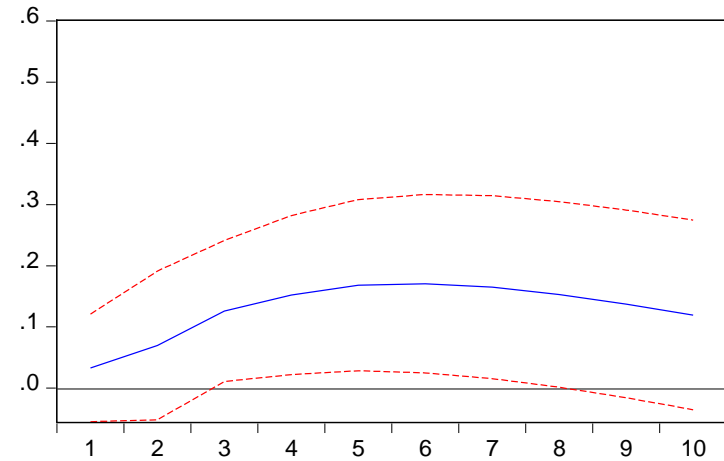
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

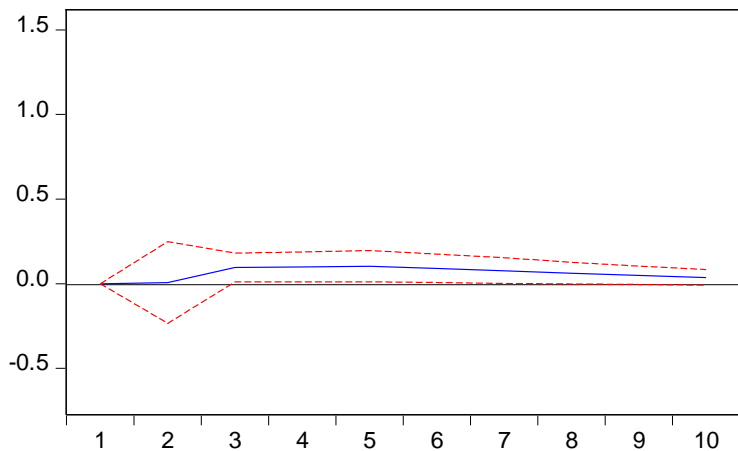


Response of Yield Spread to Unemployment rate

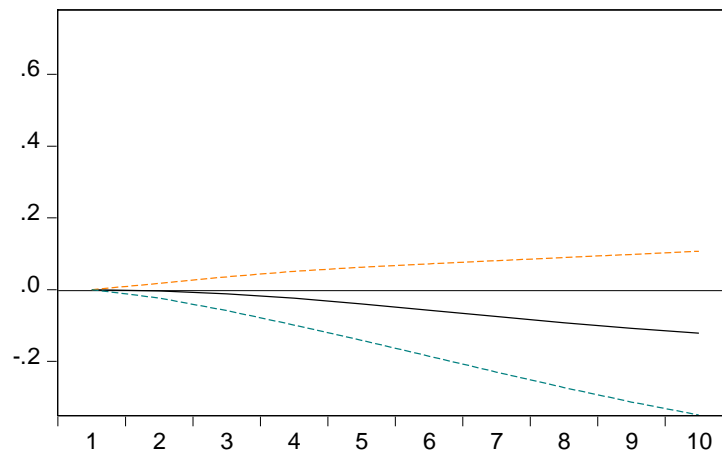


c) Germany

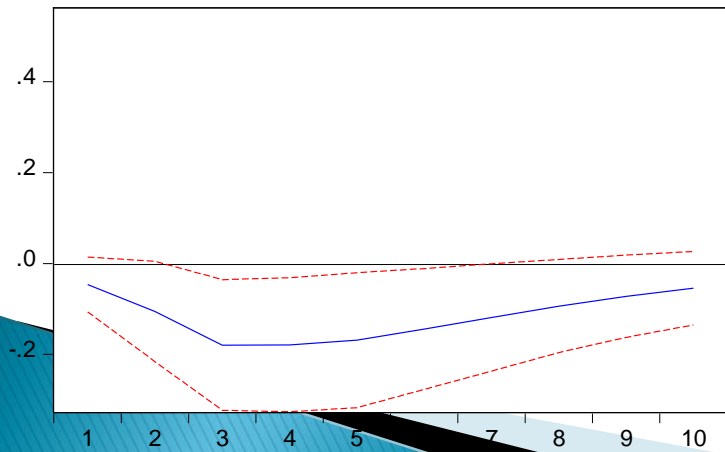
Response of GDP Growth to Yield Spread



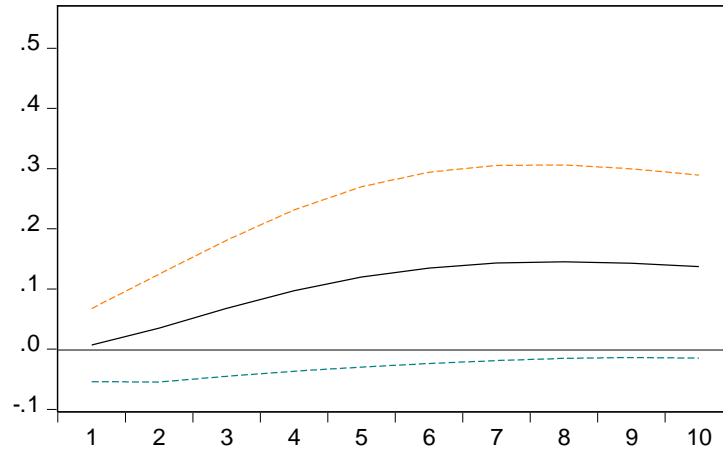
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

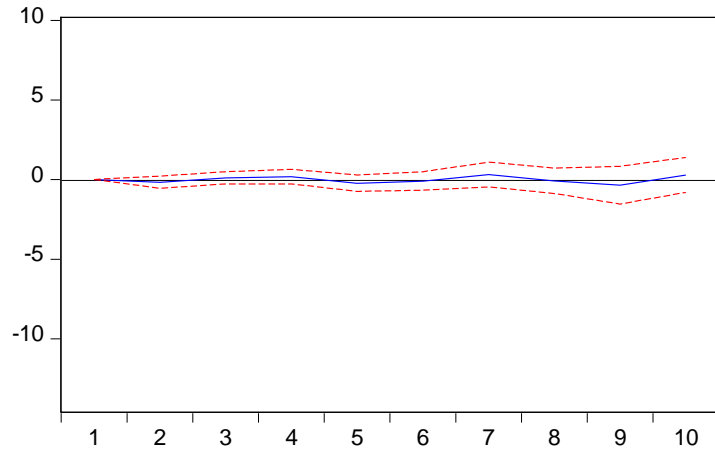


Response of Yield Spread to Unemployment rate

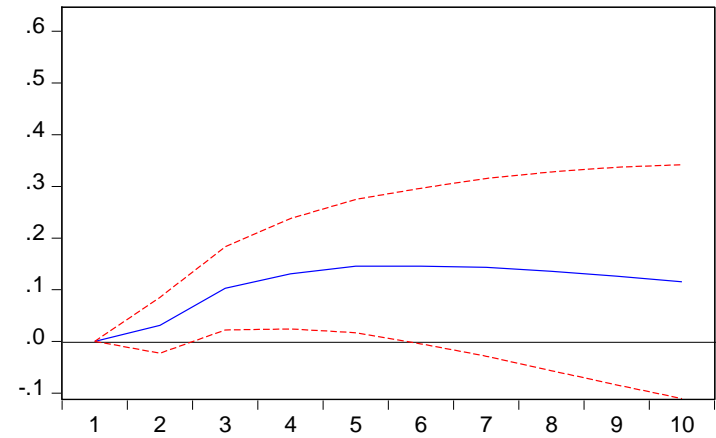


d) France

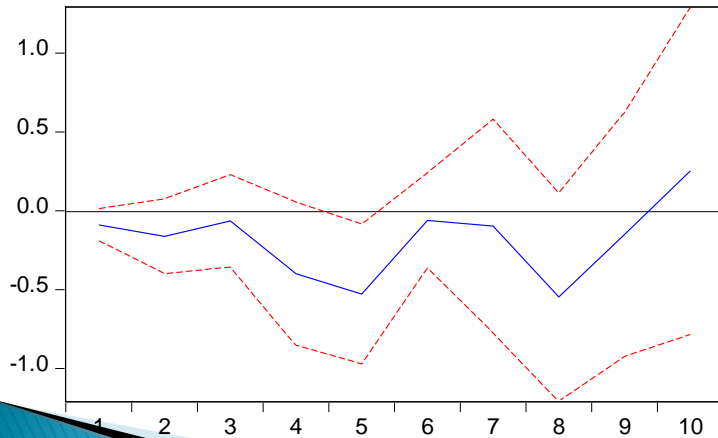
Response of GDP Growth to Yield Spread



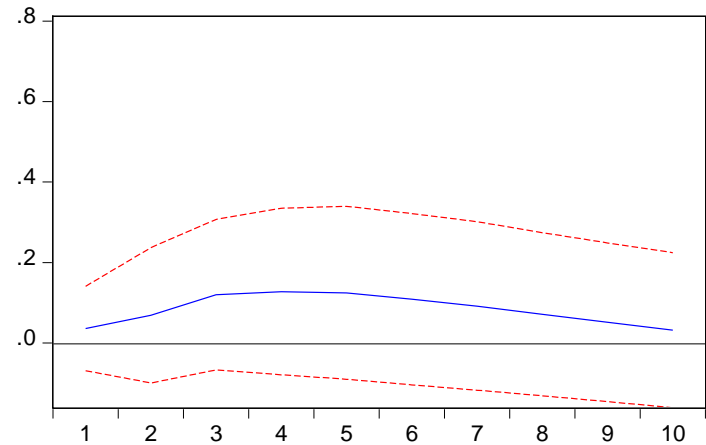
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

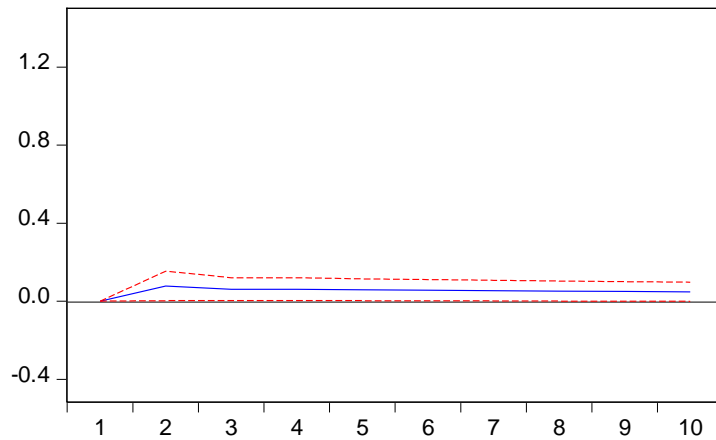


Response of Yield Spread to Unemployment rate

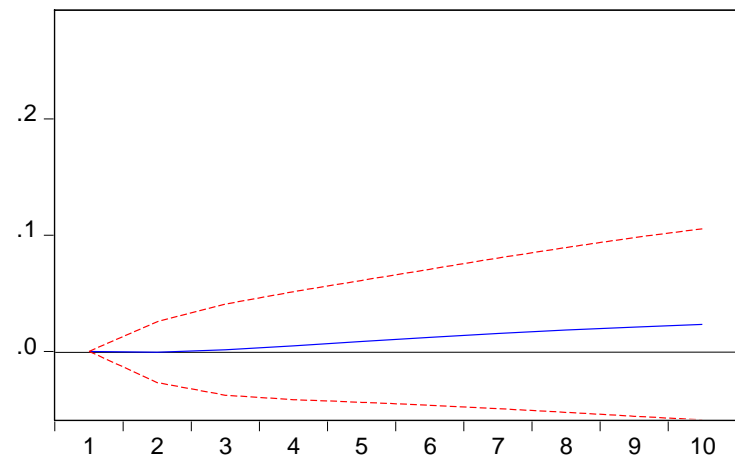


e) Japan

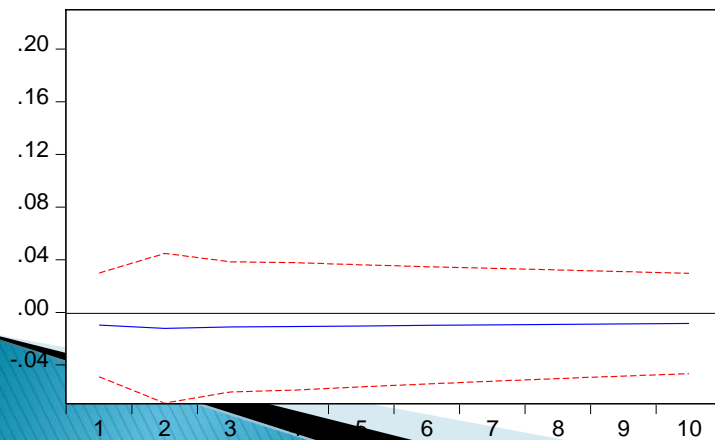
Response of GDP Growth to Yield Spread



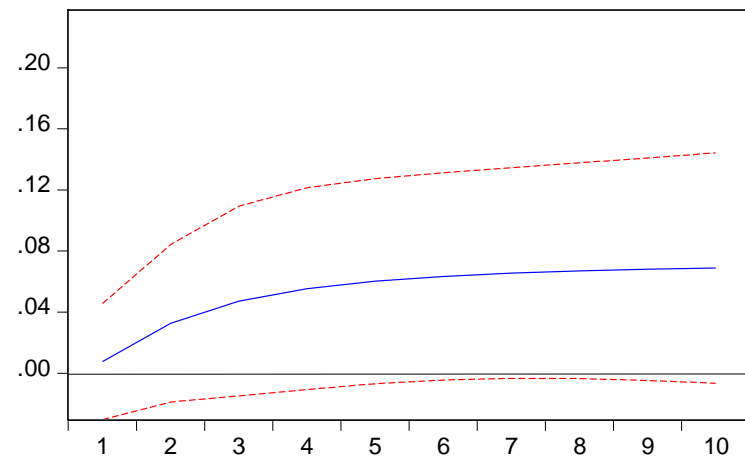
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

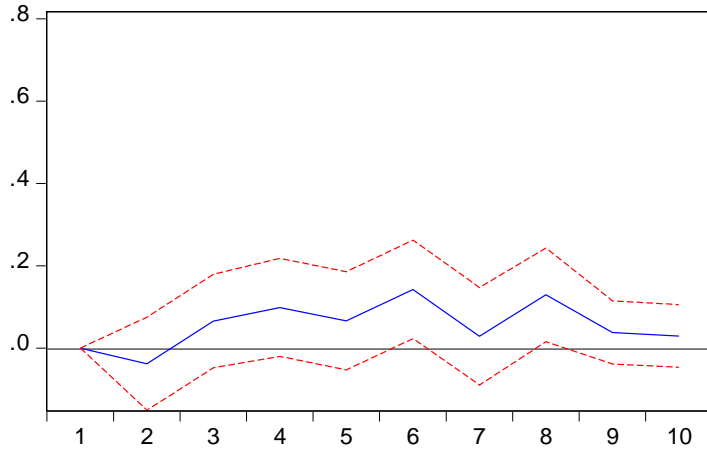


Response of Yield Spread to Unemployment rate

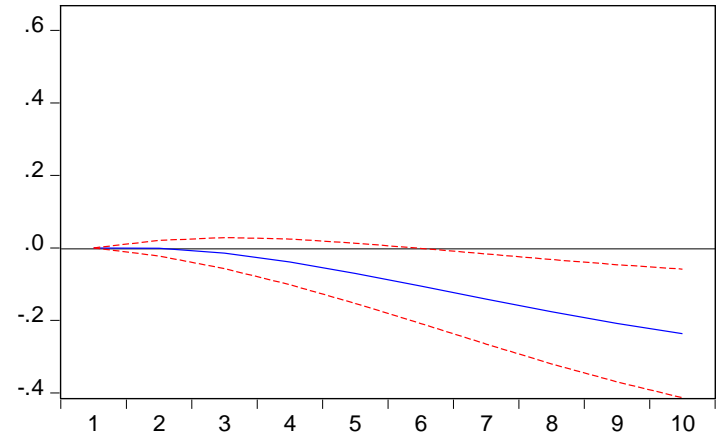


f) United Kingdom

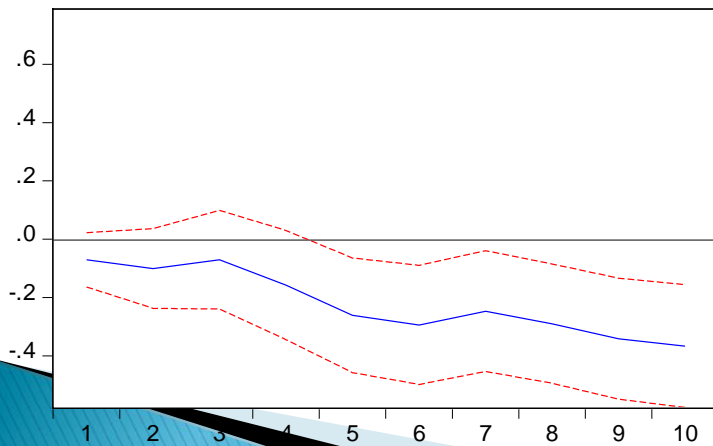
Response of GDP Growth to Yield Spread



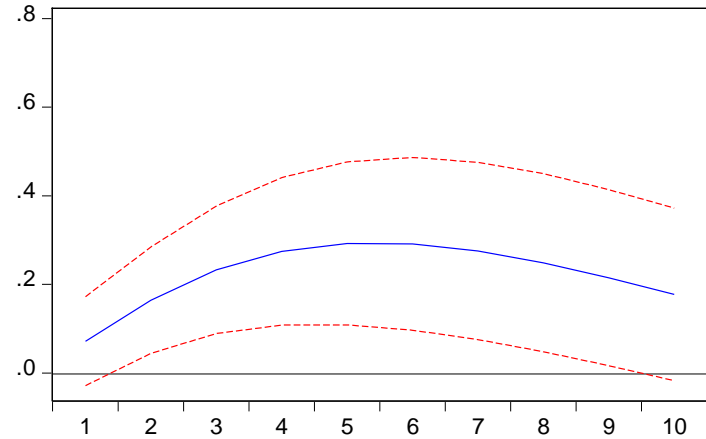
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth

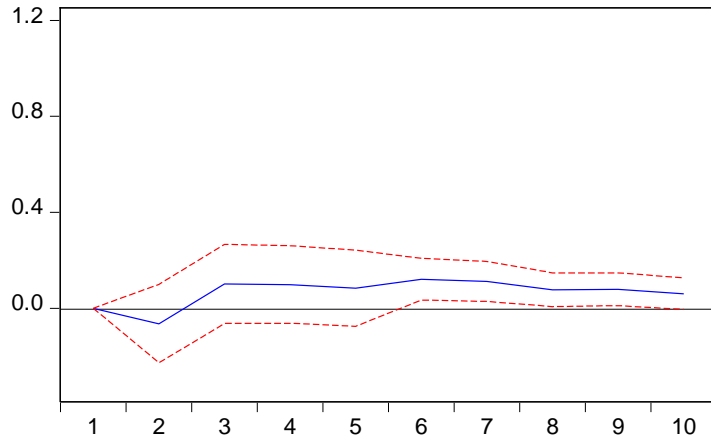


Response of Yield Spread to Unemployment rate

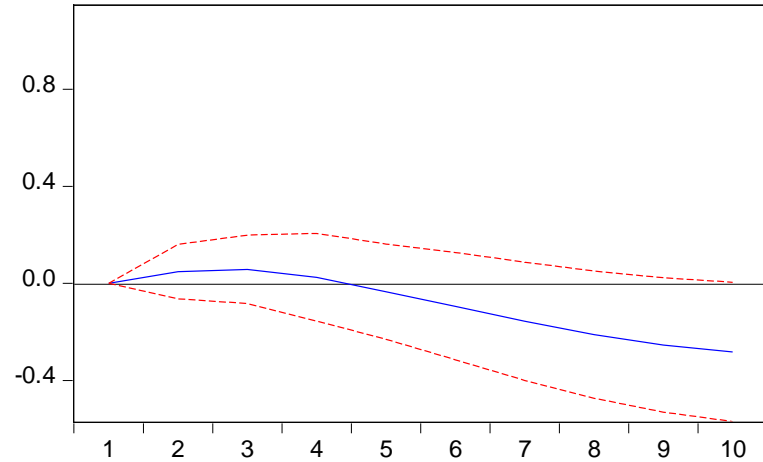


g) United States

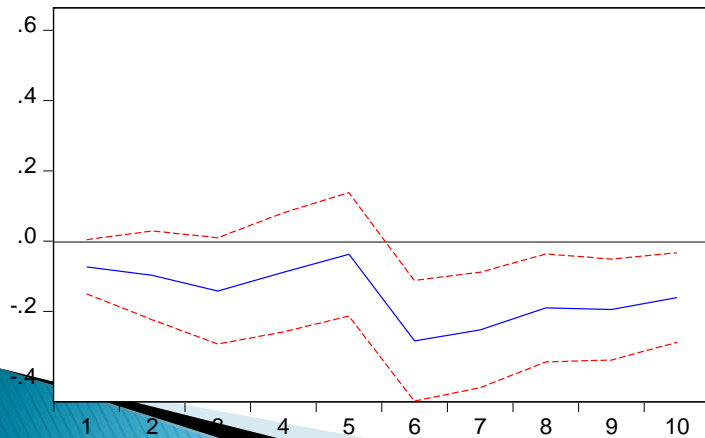
Response of GDP Growth to Yield Spread



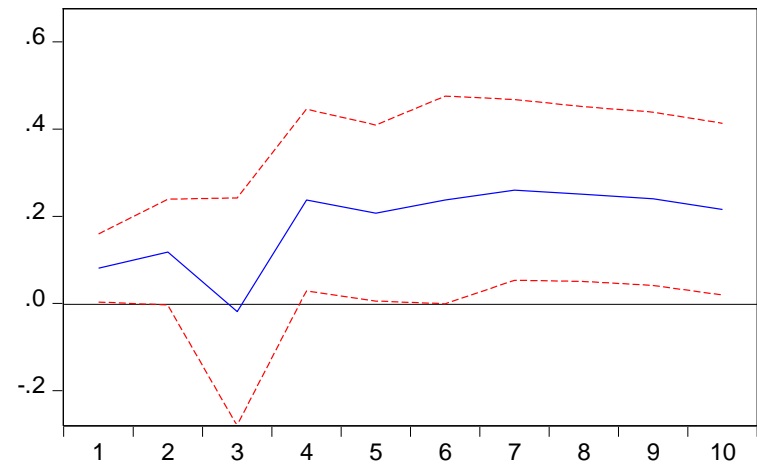
Response of Unemployment rate to Yield Spread



Response of Yield Spread to GDP Growth



Response of Yield Spread to Unemployment rate



6. Discussion

6.1 1st Part

- Yield Spread is a consistent predictor and significant for GDP [Bonser-Neal, C., & Morley, T. R. (1997).] [Haubrich, J. G., & Dombrosky, A. M. (1996)]

- The Yield Spread loses its predictive power from the 3rd year [Estrella, A., & Hardouvelis, G. A. (1991)]

- Not as significant forecast for Unemployment rate [Sarno, L., Thornton, D. L., & Valente, G. (2007)}

- Differences across the examined countries

6.2 2nd part

- Significant reaction on Yield spread's shocks for GDP [Cinquegrana, G., & Sarno, D. (2010)] [Rubaszek, M. (2016)]

- Unemployment rate loses significance for as we proceed to lags

- Larger standard errors in monthly, more significance on quarterly basis

7. Conclusion

Is yield Curve a valid predictor for GDP and Unemployment for the G7?

Multi-country analysis

For future research panel data analysis, for transnational interactions

THANK YOU FOR
YOUR
ATTENTION