SCB Economic Intelligence Center

Economic Fundamentals and Spill-over among Asian Term Structure

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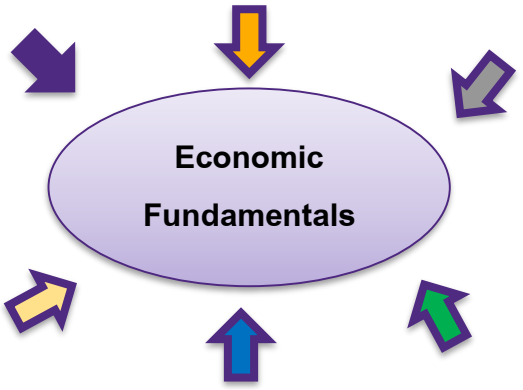
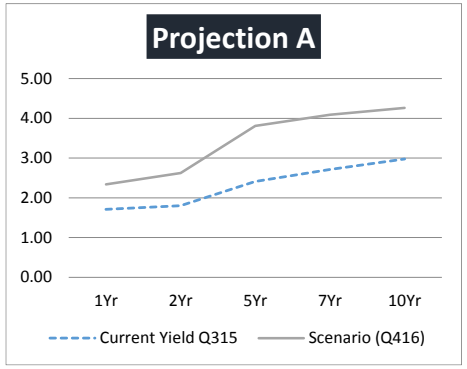
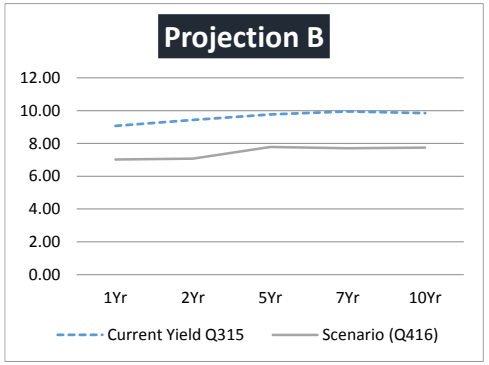
แนวคิดการพัฒนาแบบจำลอง

- To study the determinants of yield curves in the selected EM Asian countries and see the correlation among them
- To uncover whether global or local factors matter, and identify the channels of the shocks

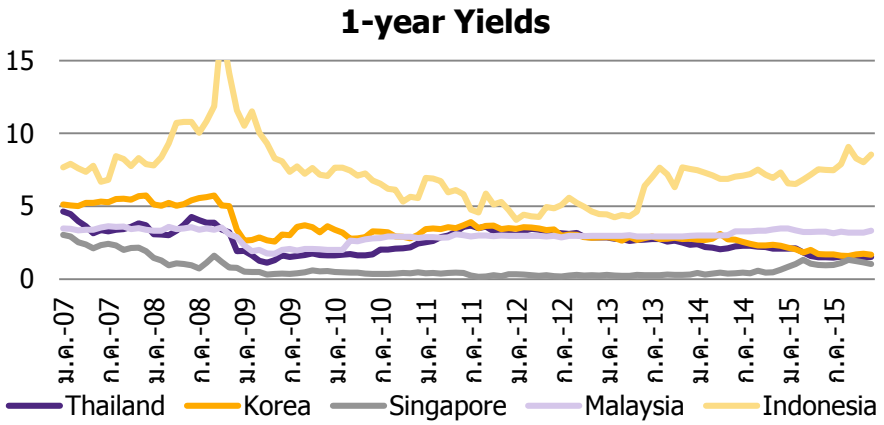


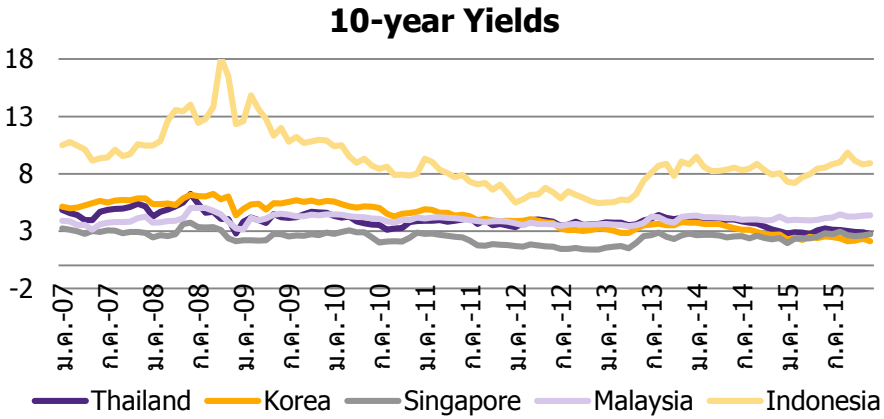




- A mixture of finance and macro models.
  - Slightly poorer fitting performance, but with clearer economic intuition under each factors

Selected EM government bond yields: Local/Global Determinants?





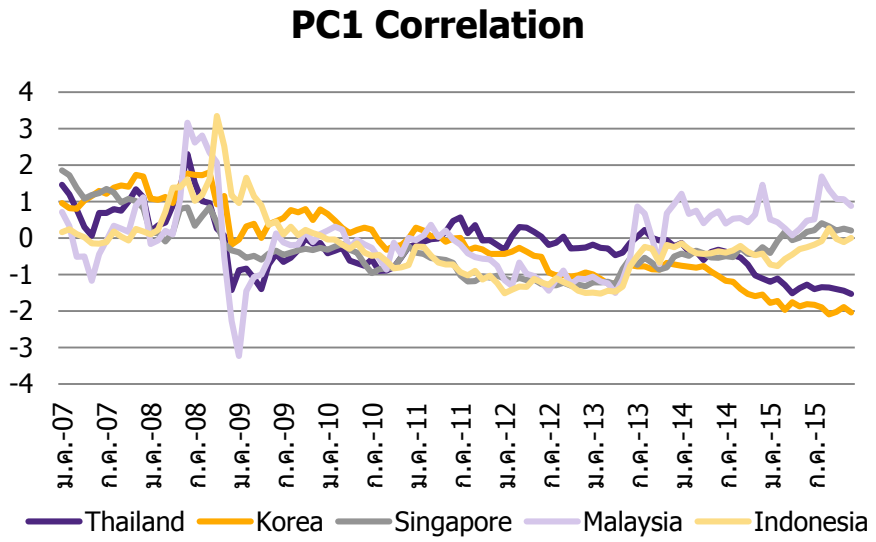
- Low correlation among short-end and real activity
- High correlation among the long-end
- There might be common factors or external factors that affect long-end yields at the same time
- Ex) TH vs KR bonds as a safe haven?

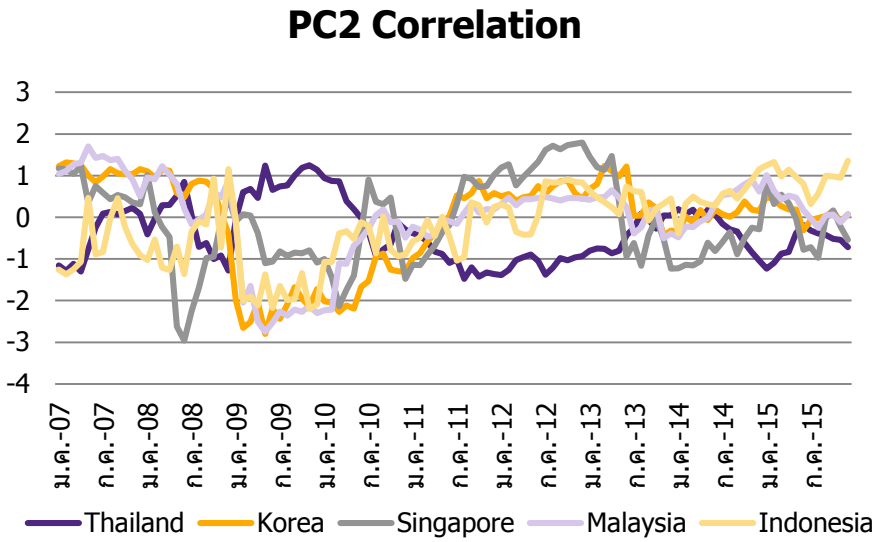
1y Corr	Korea	Singapore	Malaysia	Indonesia
Thailand	0.674	0.717	0.571	0.396
Korea		0.652	0.329	0.463
Singapore			0.524	0.615
Malaysia				0.076

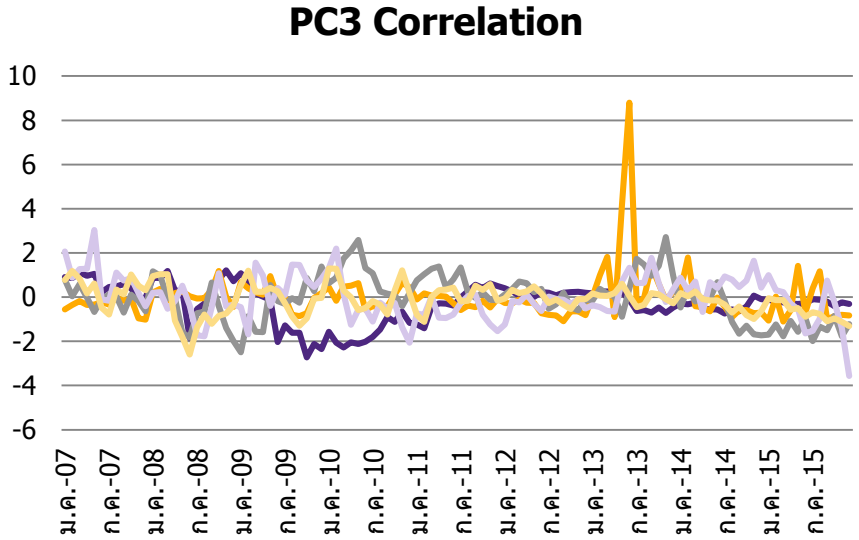
10y Corr	Korea	Singapore	Malaysia	Indonesia
Thailand	0.704	0.688	0.290	0.661
Korea		0.574	0.262	0.702
Singapore			0.631	0.724
Malaysia				0.460

ACT Corr	Korea	Singapore	Malaysia	Indonesia
Thailand	-0.172	0.138	0.536	0.080
Korea		0.146	0.071	-0.174
Singapore			0.311	0.148
Malaysia				0.170

A Closer Look: Evidence from PCA Analysis







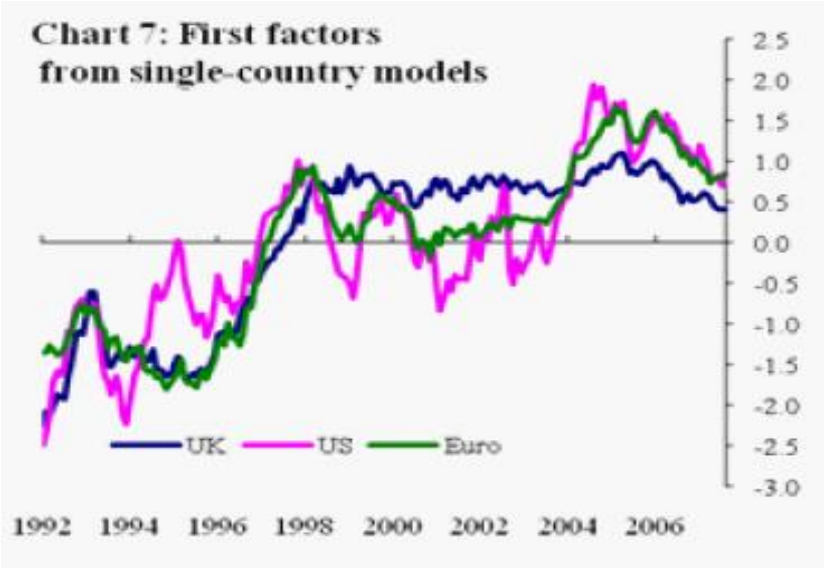
- **Dynamics of the first factors are highly correlated**
  - Existence of global factors
- **However, second and third factors appear to be less correlated**
  - Suggesting a clear role for local factors

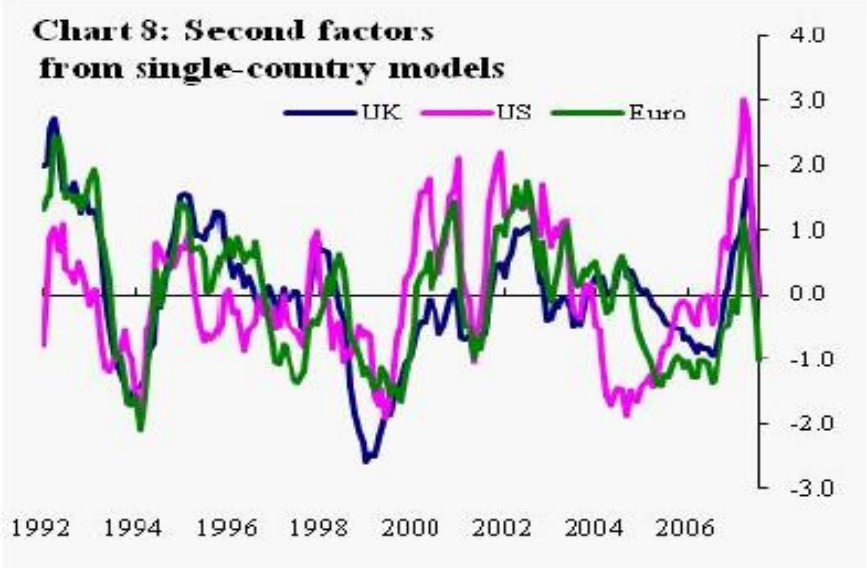
Tenor

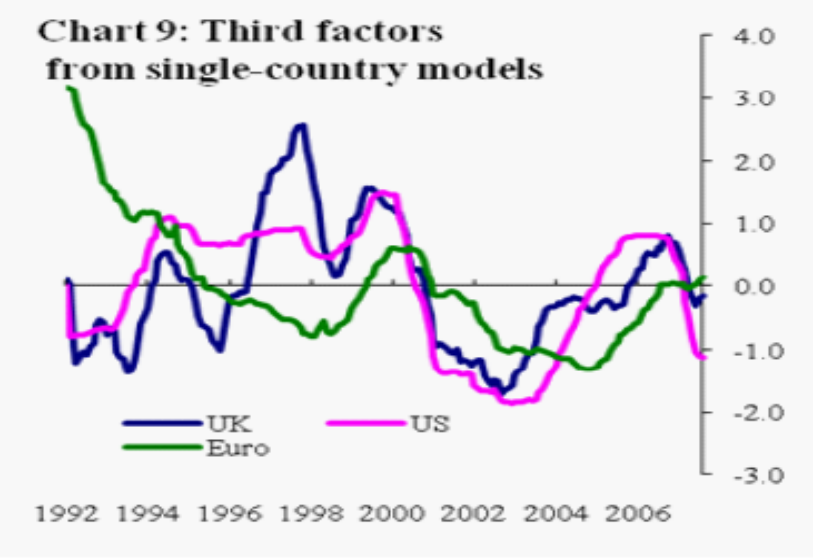
C	D	E	F	G	H	I	J	K	L	M	N	O
	Thai yields											
	3 month	6 month	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year
	F12203M I	F12206M I	F12201Y Ir	F12202Y Ir	F12203Y Ir	F12204Y Ir	F12205Y Ir	F12206Y Ir	F12207Y Ir	F12208Y Ir	F12209Y Ir	F12210Y Ir
Date	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST	PX_LAST
#NAME?	2.16	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?
31-Jan-02	2.00	2.19	2.233	2.366	2.782	3.088	3.556	3.911	4.278	4.608	4.782	5.168
28-Feb-02	2.02	2.15	2.212	2.387	2.803	3.228	3.932	4.242	4.562	4.959	5.186	5.479
29-Mar-02	1.99	2.11	2.142	2.634	2.957	3.578	4.379	4.803	5.244	5.901	6.242	6.573
30-Apr-02	1.97	2.10	2.111	2.583	2.947	3.211	3.949	4.518	5.112	5.421	5.759	6.472
31-May-02	1.96	2.10	2.131	2.459	2.803	3.249	3.863	4.502	5.171	5.506	5.788	6.247
28-Jun-02	1.90	2.04	2.172	2.295	2.69	3.146	3.748	4.367	5.015	5.283	5.361	6.238
31-Jul-02	1.86	2.00	2.141	2.339	2.693	3.089	3.699	4.121	4.558	5.251	5.255	5.691
30-Aug-02	1.77	1.91	1.998	2.043	2.36	2.641	3.295	3.648	4.011	4.582	4.657	5.137
30-Sep-02	1.80	1.94	1.984	2.121	2.256	2.538	2.962	3.212	3.469	4.016	4.051	4.732
31-Oct-02	1.86	1.99	1.985	2.154	2.263	2.44	2.802	3.188	3.584	3.902	3.931	4.316
29-Nov-02	1.70	1.77	1.806	1.935	2.023	2.184	2.453	2.897	3.355	3.688	3.73	4.082
31-Dec-02	1.66	1.73	1.779	1.914	2.03	2.227	2.448	2.884	3.333	3.543	3.721	4.01
31-Jan-03	1.55	1.58	1.586	1.703	1.834	2.027	2.149	2.492	2.843	3.056	3.26	3.513
28-Feb-03	1.44	1.47	1.476	1.628	1.759	1.894	2.091	2.393	2.701	2.989	3.014	3.715
31-Mar-03	1.58	1.61	1.628	1.691	1.817	1.934	2.238	2.539	2.847	3.228	3.263	3.729
30-Apr-03	1.60	1.63	1.651	1.713	1.78	1.912	2.134	2.469	2.811	3.077	3.108	3.659
30-May-03	1.60	1.62	1.643	1.699	1.719	1.815	1.945	2.198	2.455	2.643	2.769	2.928
30-Jun-03	1.43	1.46	1.473	1.525	1.544	1.593	1.625	1.775	1.926	2.156	2.258	2.6
31-Jul-03	1.20	1.22	1.224	1.291	1.402	1.642	1.899	2.173	2.452	2.662	2.723	3.131
29-Aug-03	1.17	1.18	1.236	1.451	1.565	1.774	2.251	2.554	2.865	3.15	3.252	3.408
30-Sep-03	1.23	1.18	1.207	1.377	1.493	1.751	2.174	2.564	2.966	3.35	3.38	3.909
31-Oct-03	1.30	1.32	1.318	1.595	1.803	2.331	2.667	3.308	3.977	4.019	4.153	4.608

Date

Evidence in DM countries



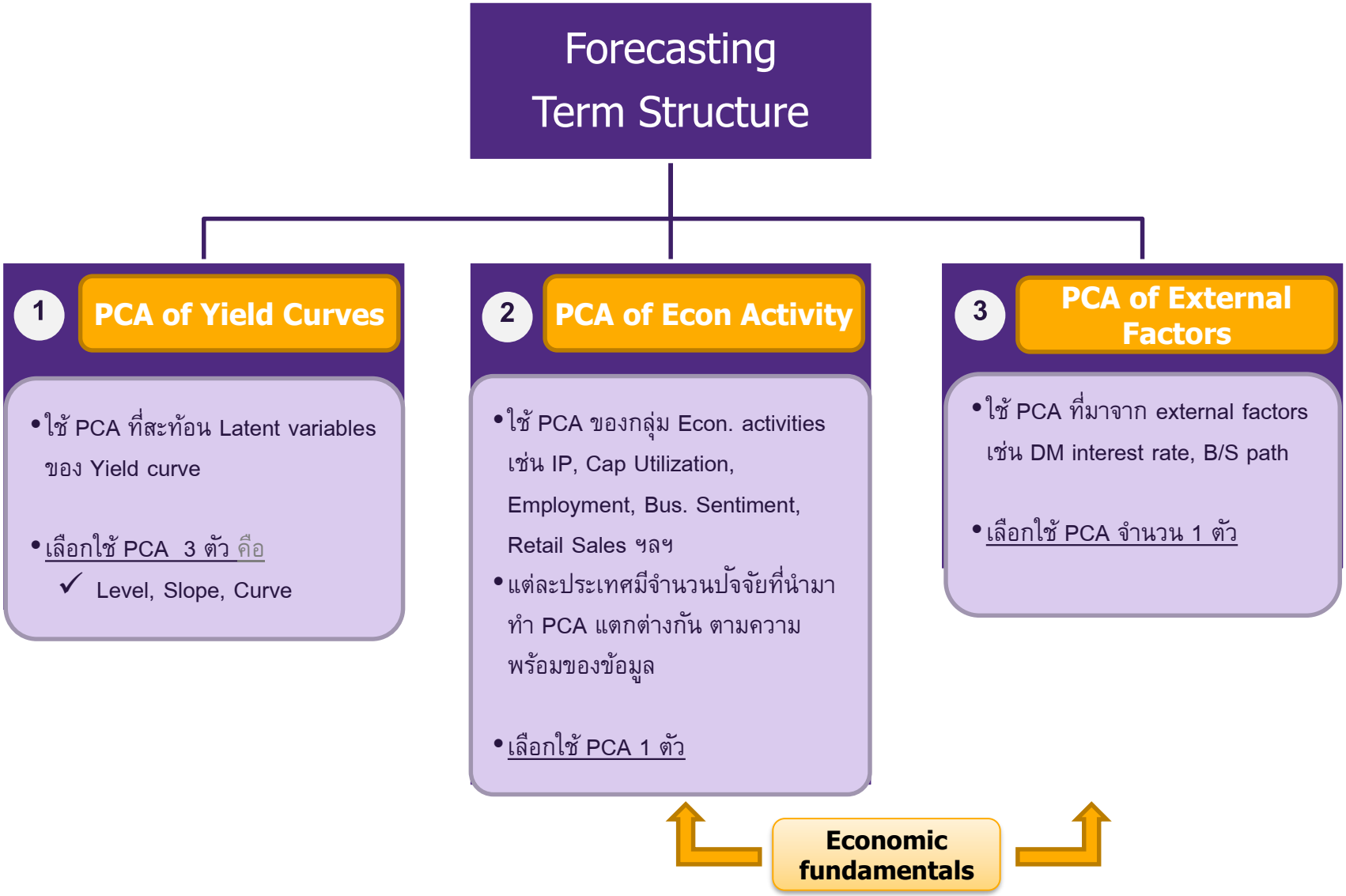




- **Evidence from DM countries also suggest the same inference**

(Ref: ACM 2015)

โครงสร้างแบบจำลอง



Interpretation of Latent factors: PC1, PC2, and PC3

In Financial Literatures

- **PC1 is level factor**
  - ➢ Weighted average of yields level
- **PC2 is the slope factor**
  - ➢ The difference between long-end (10y) and short-end (1y)
- **PC3 is the curvature**
  - ➢ The sum of short-end and long-end yield minus the middle part of the yield curve

In Economic Literatures

- **PC1 is perceived inflation target**
  - ➢ relate to inflation expectation
- **PC2 is the cyclical monetary policy response**

Back

สรุปปัจจัยที่สะท้อน economics activities ของแต่ละประเทศในการทำ Principal Component Analysis (PCA)

ประเทศ	จำนวนปัจจัยที่ใช้ทำ PCA	Domestic factors	Global factors
Thailand	6	MPI, Coincidence index, Retail sales, Bus. sentiment	Commodity Price, DM Rate
Korea	7	Cap Utilization, IP, Construction orders, Manu business Survey, Employment	Commodity Price, DM Rate
Singapore	5	New order, PMI, Retail Sales	Commodity Price, DM Rate
Indonesia	6	IP, Household debt, Capital adequacy ratio, NPL	Commodity Price, DM Rate
Malaysia	6	Coincident economics indicator, Wage growth, Household credit	Commodity Price, DM Rate

Theory and Underlying Assumptions

No arbitrage theory, with existence of pricing kernel

$$P_t^n = E_t[M_{t+1} P_{t+1}^{n-1}] \qquad \text{(no arbitrage)}$$

$$M_{t+1} = exp\left[-r_t - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\Sigma^{-1/2} v_{t+1}\right] \qquad \text{(pricing kernel)}$$

$$\lambda_t = \Sigma^{-1/2}(\lambda_0 + \lambda_1 X_t) \qquad \text{(market price of risk)}$$

Definition: Log excess return

$$rx_{t+1}^{n-1} = \ln P_{t+1}^{n-1} - \ln P_t^n - r_t$$

Estimate price of risk (λ) and pricing parameters for term structure

$$y_t^{(n)} = \ln P_t^{(n)} = A_n + B_n X_t + u_t^{(n)} \qquad \text{(yields as a function of state variables)}$$

สรุปขั้นตอนการทำ Estimation และ Forecast

ทำ PCA ของปัจจัยต่าง ๆ

๖กำหนด Dynamic process ของ factor)

- ทำ PCA ของ Factor
- กำหนด Dynamic process ของ factor ทั้ง 5 ตัว เป็น VAR(1)

$$\begin{bmatrix} x_t^1 \\ x_t^2 \\ \dots \\ x_t^7 \end{bmatrix} = \begin{bmatrix} \mu^1 \\ \mu^2 \\ \dots \\ \mu^7 \end{bmatrix} + \begin{bmatrix} k_1^1 & k_2^1 & \dots & k_7^1 \\ k_1^2 & k_2^2 & \dots & k_7^2 \\ \dots & \dots & \dots & \dots \\ k_1^7 & k_2^7 & \dots & k_7^7 \end{bmatrix} \begin{bmatrix} x_{t-1}^1 \\ x_{t-2}^2 \\ \dots \\ x_{t-7}^7 \end{bmatrix} + \begin{bmatrix} \varepsilon_t^1 \\ \varepsilon_t^2 \\ \dots \\ \varepsilon_t^7 \end{bmatrix}$$

- ใช้ข้อมูลเป็นรายเดือน
- Dynamic process ที่คำนวณได้ จะใช้ในการ Forecast factor และ Yield curve ในอนาคต

หาความสัมพันธ์กับ Yield Curve

- Regress bond excess return over factors using OLS
- กำหนด holding period return เท่ากับ 1 เดือน
- Excess return คำนวณดังนี้ $rx_{t+1}^{(n-1)} = \log P_{t+1}^{(n-1)} - \log P_t^{(n)} - r_t.$
- Run regression สำหรับ Yield curve ทุก tenor

$$rx = \mathrm{a}\iota_T' + \beta'\hat{V} + \mathrm{c}X_- + E.$$

tenors

Number of factors

Transform factors into yield through price of risk

- Model yield curve ทั้งสิ้น 120 tenor ได้แก่ 1 เดือน ถึง 10ปี
- ภายใต้ทฤษฎีของ Affine term structure model นำค่า parameters ที่ได้จากขั้นที่ 2 มาคำนวณหาค่าสัมประสิทธิ์ Price of risk

$$\lambda_0 = (\hat{\beta}\hat{\beta}')^{-1}\hat{\beta}\left(\hat{a} + \tfrac{1}{2}(\hat{B} * vec(\hat{\Sigma}) + \sigma^2 i_N)\right)$$

- นำค่า (λ) ที่ได้ไปใช้คำนวณ pricing parameters ในการหา yields

$$y_t^{(n)} = \ln P_t^{(n)} = A_n + B_n X_t + u_t^{(n)}$$

$$A_n = A_{n-1} + B_{n-1}'(\mu - \lambda_0) + \frac{1}{2}\left(B_{n-1}'\Sigma B_{n-1} + \sigma^2\right) - \delta_0,$$

$$B_n' = B_{n-1}'(\Phi - \lambda_1) - \delta_1',$$

Forecast

- Forecast dynamics ของ factors ออกไปในอนาคต (15 เดือนข้างหน้า) โดยใช้ค่า coefficients ที่ได้จากขั้นตอนที่1
- นำค่า factors ที่ได้จากการ forecast มาแปลงเป็น yield โดยใช้สัมประสิทธิ์จากขั้นตอนที่ 3
- สามารถทำ shock scenario หรือใส่ view เข้าไปใน factors ได้
- หาก factor ที่ต้องการ shock เป็นส่วนประกอบของ PCA กลุ่มนั้น ๆ ก็สามารถปรับ factors นั้นได้โดยตรงก่อนนำมาหา PCA
- หาก factor นั้นไม่ใช่องค์ประกอบของ PCA จำเป็นต้องดูความสัมพันธ์(regression) ของ factor นั้นต่อกลุ่ม PCA ที่มี แล้วค่อยปรับแก้ที่ PCA

Decomposing Term Structure

$$y_t^{(n)} = \underbrace{\frac{1}{n}\sum_{i=0}^{n} E_t r_{t+i}}_{1} + \underbrace{TP_t^{(n)}}_{2}$$

1. Risk-neutral yields:

- Constructed base on expectation hypothesis that long term yield is acquired by compounding and roll-over the short term yields
- Setting the price of risk parameter (λ) to zero
- The expected monetary policy path

$$\frac{1}{n}\sum_{i=0}^{n} E_t r_{t+i} = -\frac{1}{n}[A_n^{RF} + B_n^{\prime RF} X_t]$$

2. Term Premium:

- The component that accounts for additional compensation that investors require in order to hold longer-maturity bonds
- Reflect that investors are risk-averse and they consider time-valuation of money

Unspanned Macroeconomic Variables

Methodology

- Macro variables span in Historical measure

$$\begin{bmatrix} X_t^s \\ X_t^u \end{bmatrix} = \mu + \Phi \begin{bmatrix} X_{t-1}^s \\ X_{t-1}^u \end{bmatrix} + \begin{bmatrix} v_t^s \\ v_t^u \end{bmatrix},$$

- Macro variables are unspanned under Pricing measure

$$\ln P_t^{(n)} = A_n + B_n' X_t + u_t^{(n)}.$$

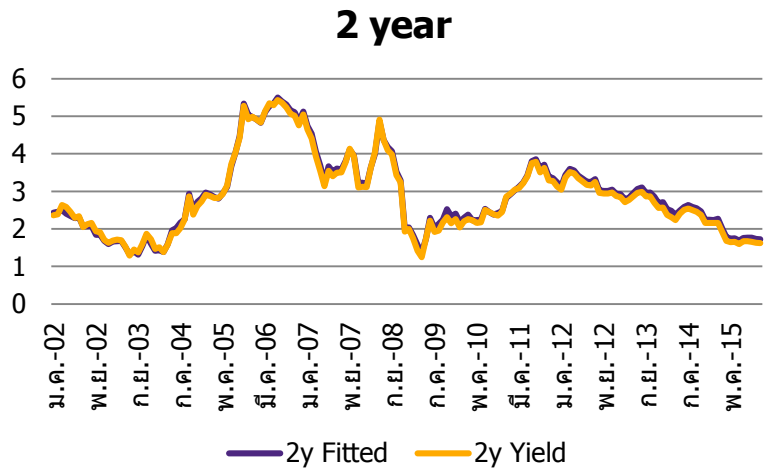
$$\Phi^\star = \begin{bmatrix} \Phi_{ss} - \lambda_1^{ss} & 0 \\ \Phi_{us} - \lambda_1^{us} & \Phi_{uu} - \lambda_{uu}^1 \end{bmatrix}.$$

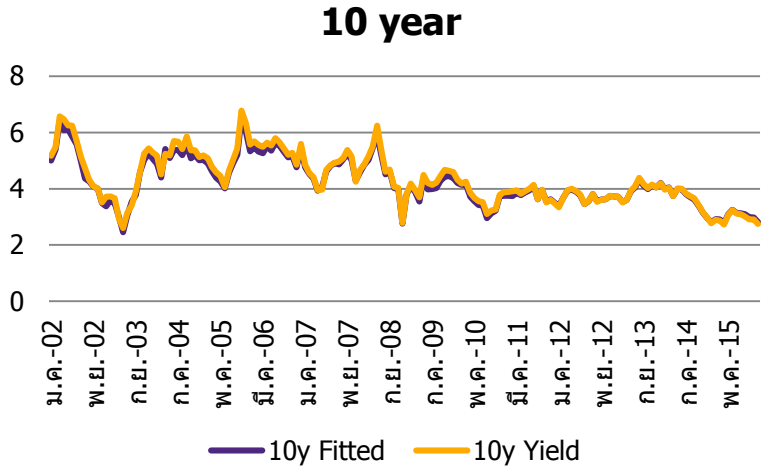
Benefits

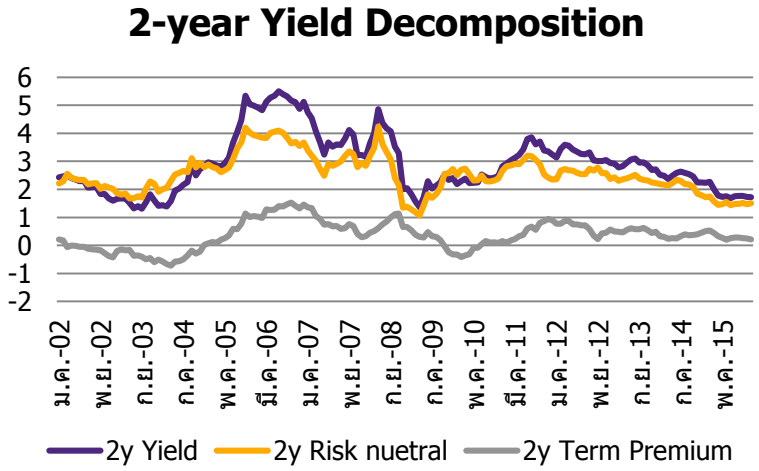
- Good fitting performance
- Economic interpretation

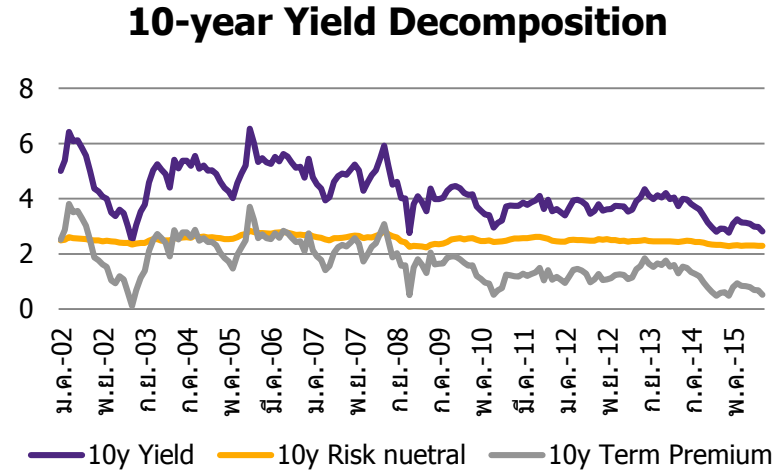
- Reference: Joslin, Le, Singleton (2012) Joslin, Priebsch ,Singleton (2014)

Fitted Yield & Term Structure Decomposition : Thailand

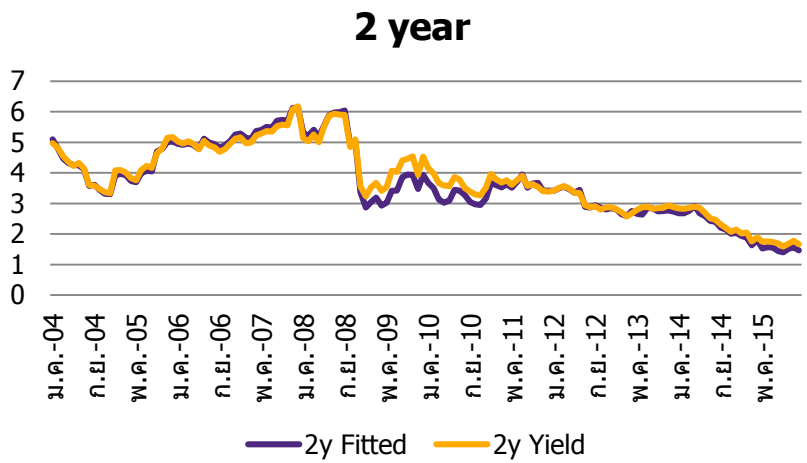


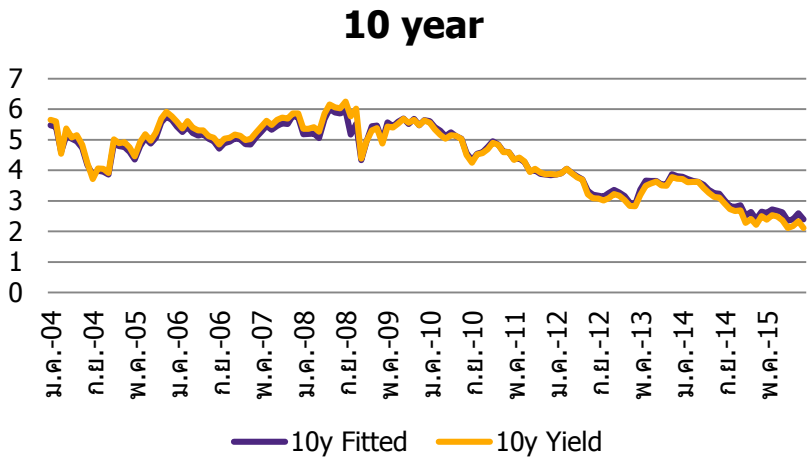


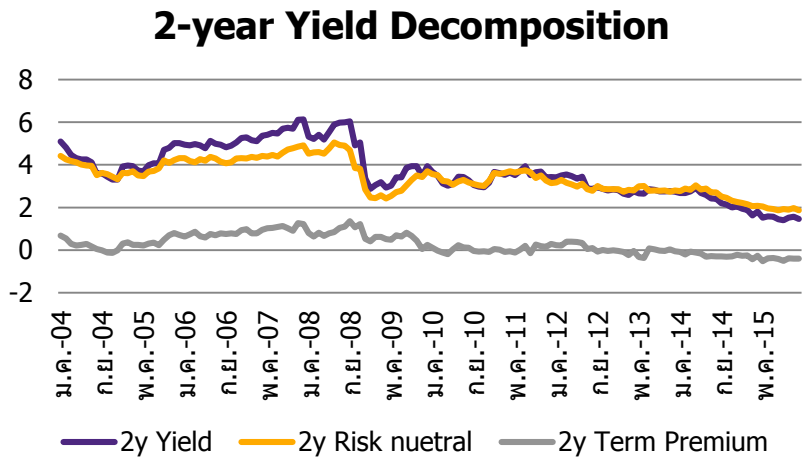


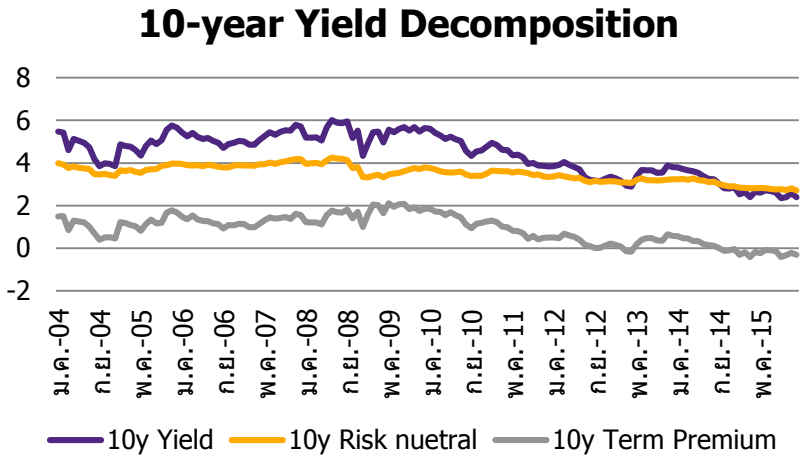


Fitted Yield & Term Structure Decomposition : Korea

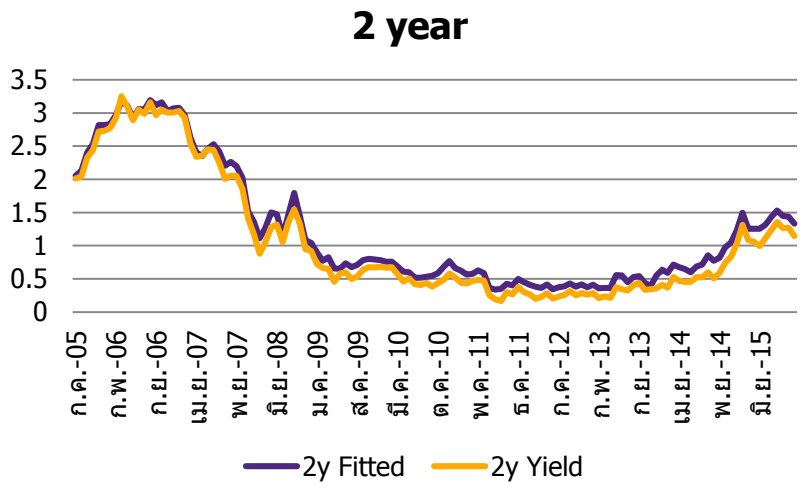


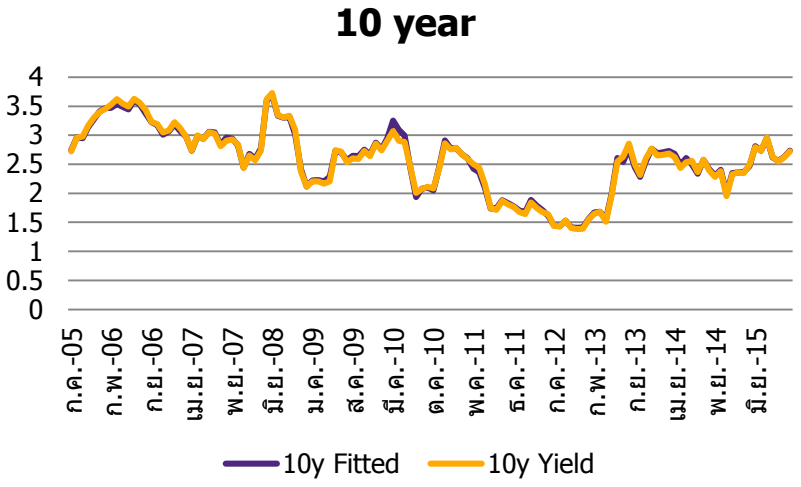


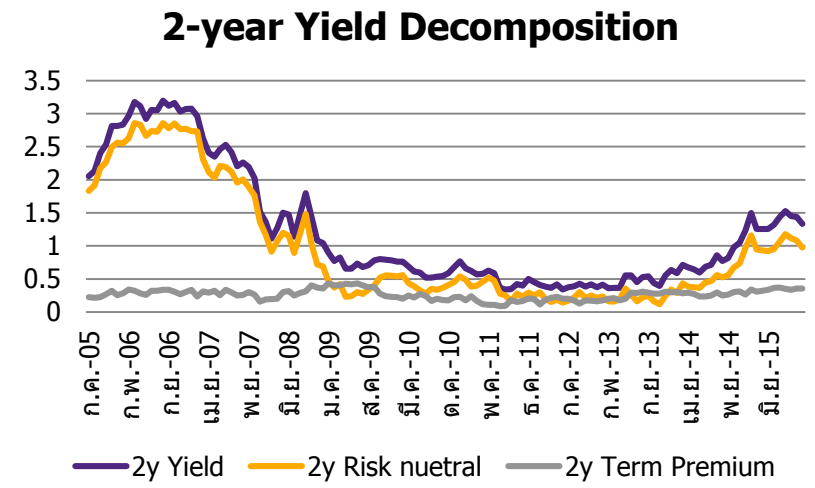


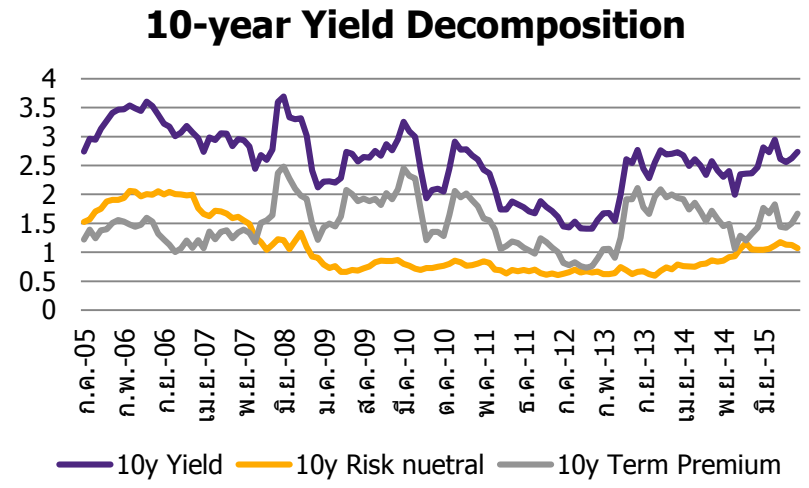


Fitted Yield & Term Structure Decomposition : Singapore

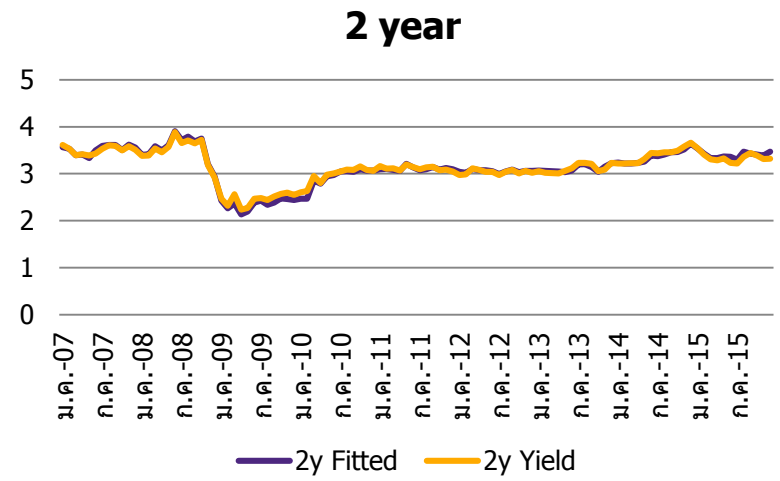


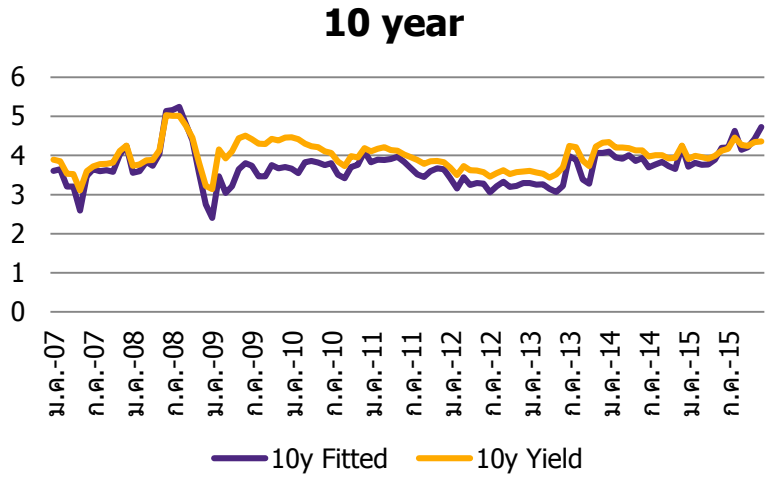


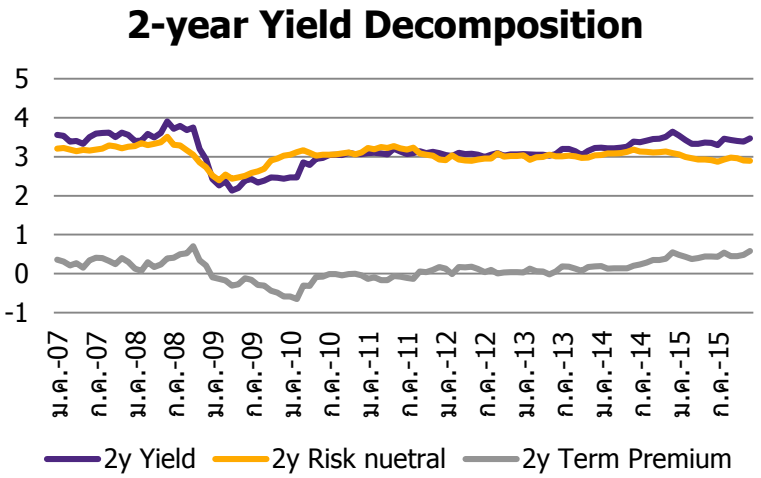


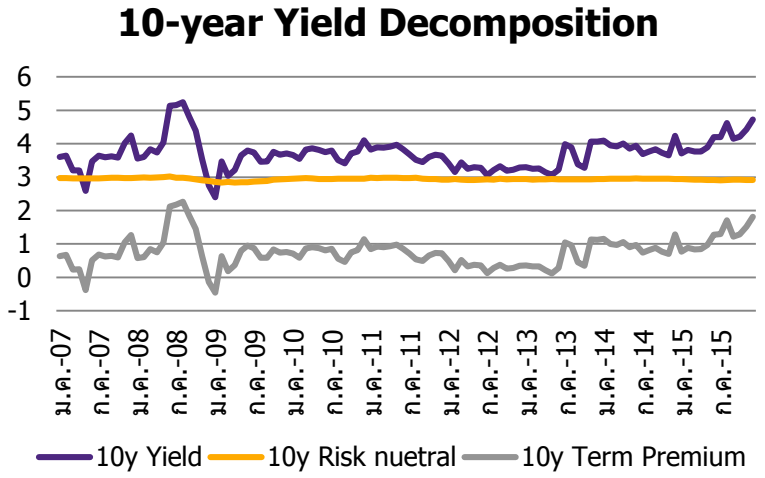


Fitted Yield & Term Structure Decomposition : Malaysia

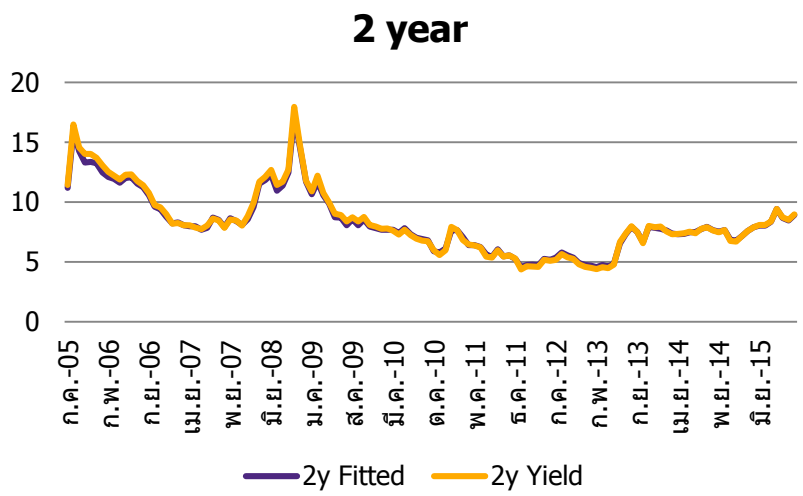


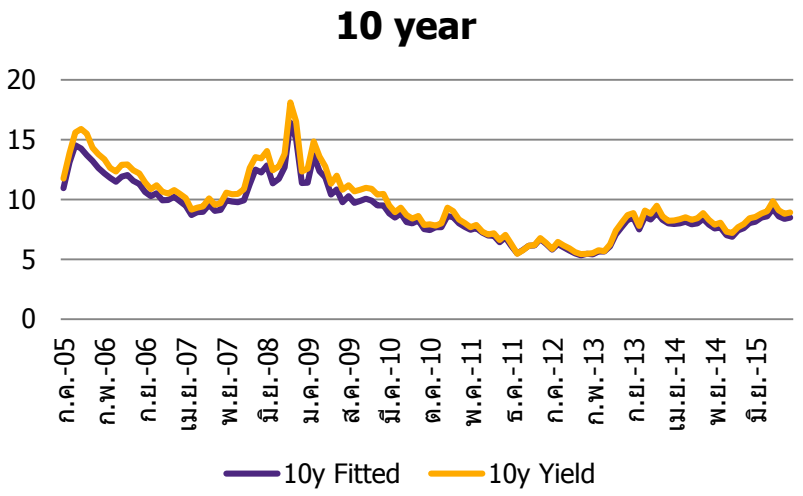


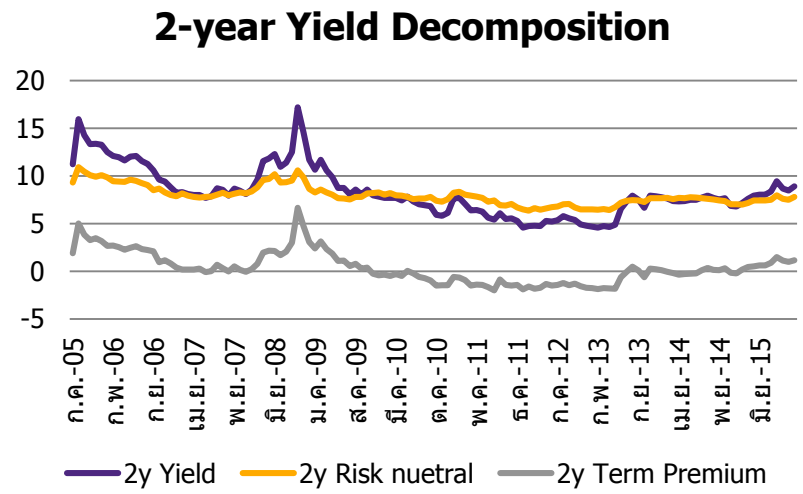


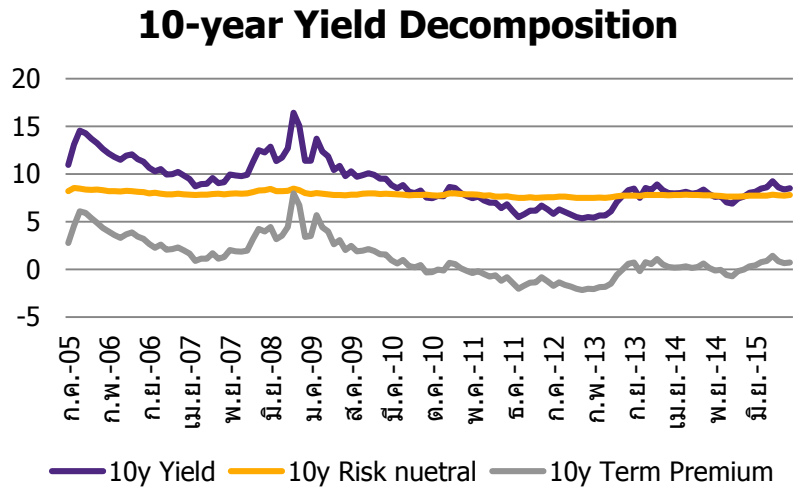


Fitted Yield & Term Structure Decomposition: Indonesia





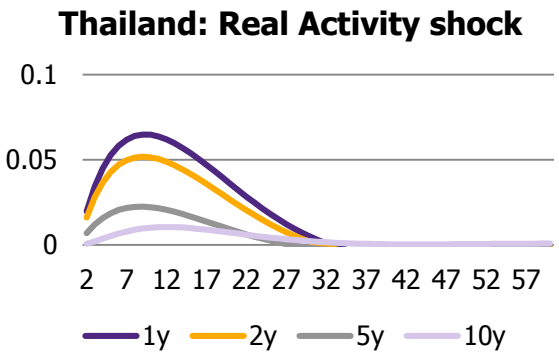


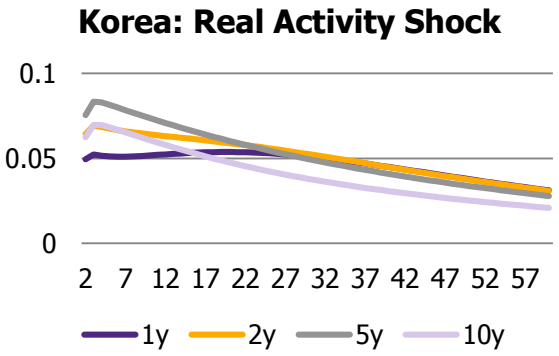


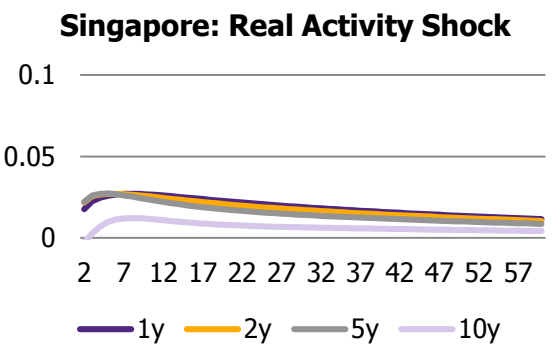
Impulse Response Analysis

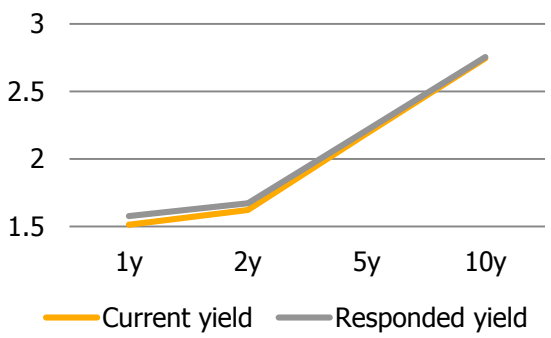
1. Real activity shock
2. Commodity price shock
3. DM policy rate shock

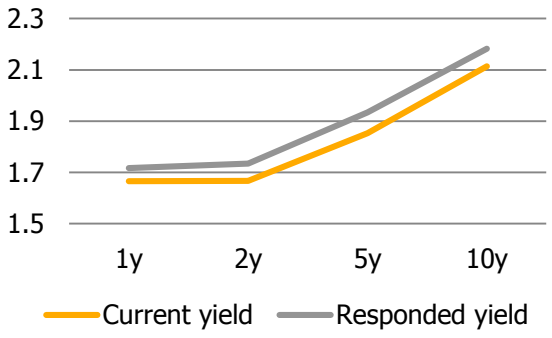
1. Local Factor: Real Activity Shock

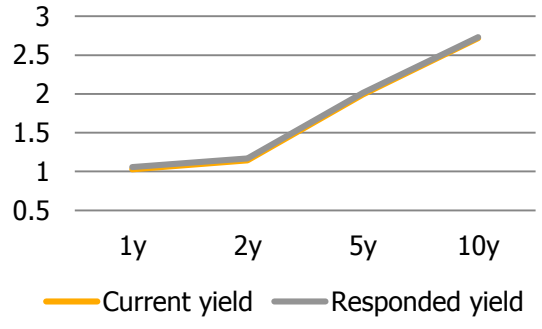




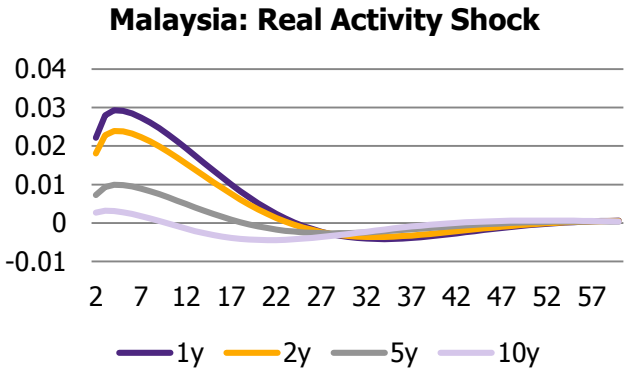


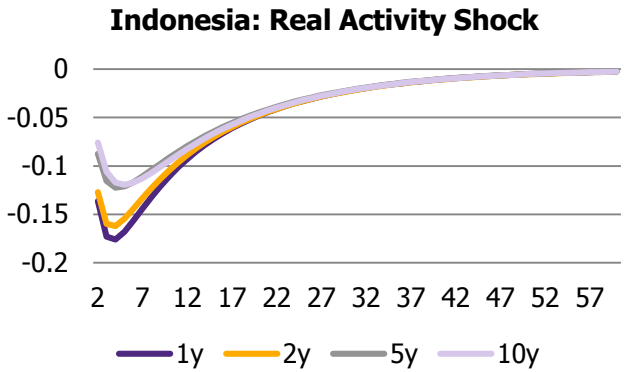


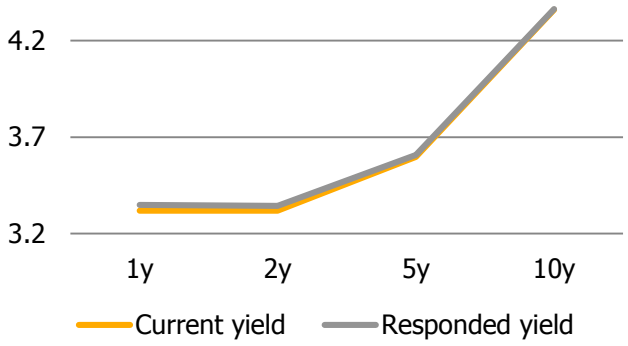


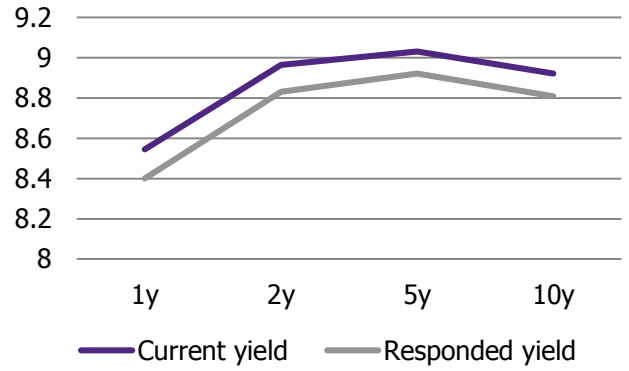


1. Local Factor: Real Activity Shock









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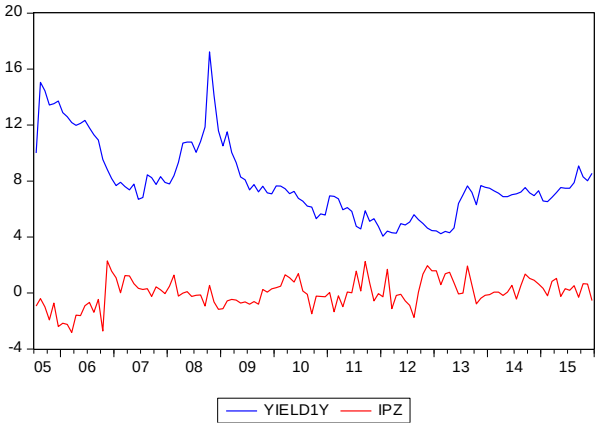
1. Local Factor: Real Activity Shock

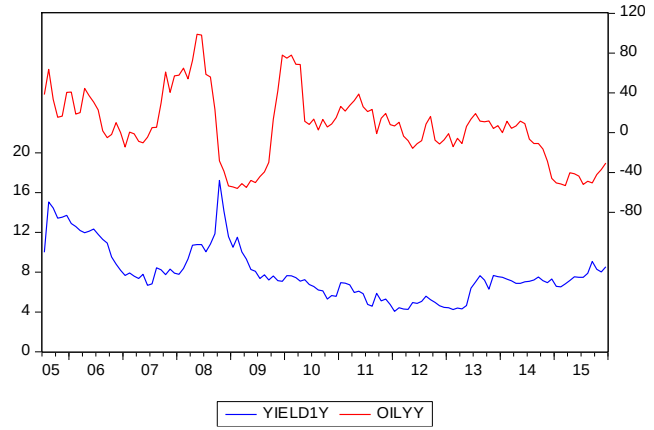
- A positive shock to real activity result in an upward shift of yield curves.
  - Higher economic growth would drive up inflation expectation.
  - Level factor (PC1) would adjust following the change in inflation expectation of private agents thus driving up yields curves.
  - Identification of PC1 with the percieved inflation target: Rudebusch, Wu (2008), Horndahl et al. (2006)
- The slope is "bear-flattening"
  - Short-end of the curve tend to be more affected by the economic activity and policy reaction
  - Ang, Piazessi (2003),
- The response of real activity variable dies down quite fast (5-10 months)

- However, the response of level factor tend to last longer and adjust back incompletely as an effect of change in inflation expectation path
- The gradual dynamic of level factor is an evidence of a slow partial adjustment of the policy interest rate (e.g. policy inertia, interest rate smoothing) see Clarida et al. (2000)

Indonesian Bonds: Correlation with economic activity indicator



Correlation
-0.471



Correlation
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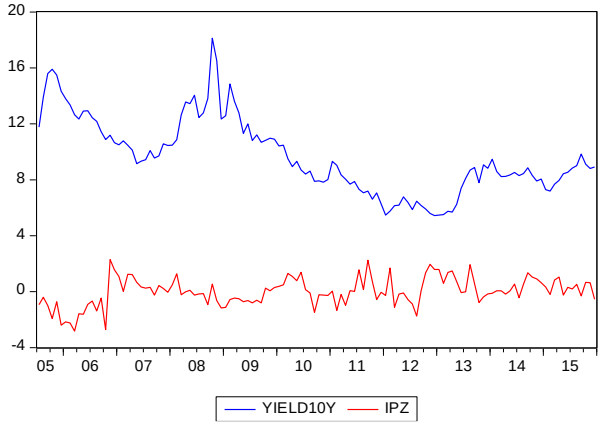

Correlation
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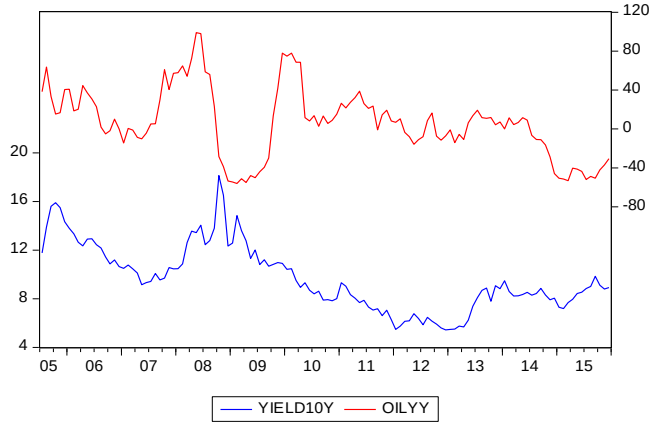
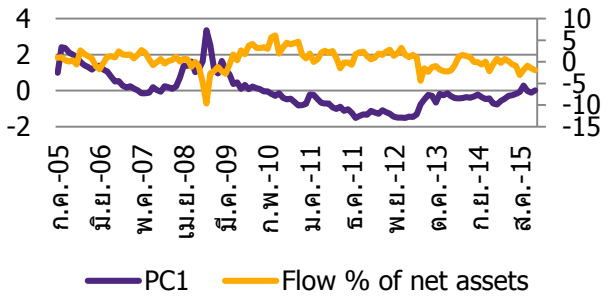


Correlation
0.19

Story of Indonesian Bonds: Evidence from previous studies

- So the plausible explanation is that when there is a positive shock in real activity, foreign flows come into the country driving up bonds price and thus decrease their yields
- Some evidence of bond flows (using EPFR) and Indonesian yields also suggest so

Bond Flow & Level Factor



Correlation
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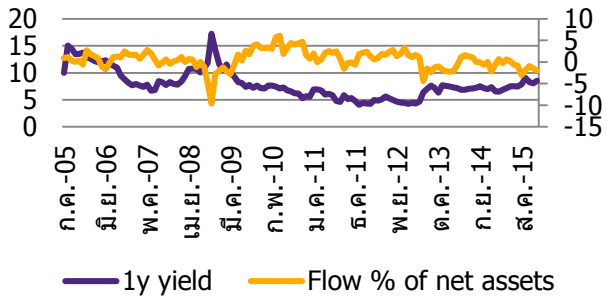
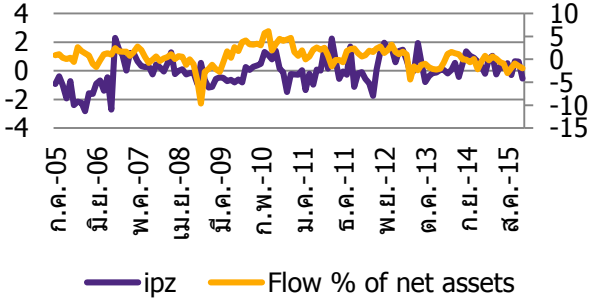
Bond Flow & Yields



Correlation
-0.40

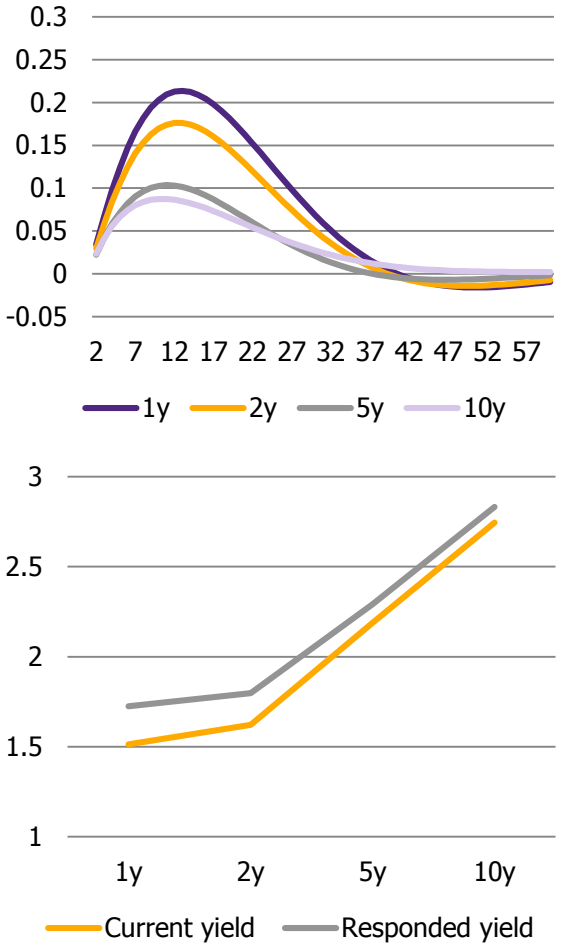
Bond Flow & Real Activity



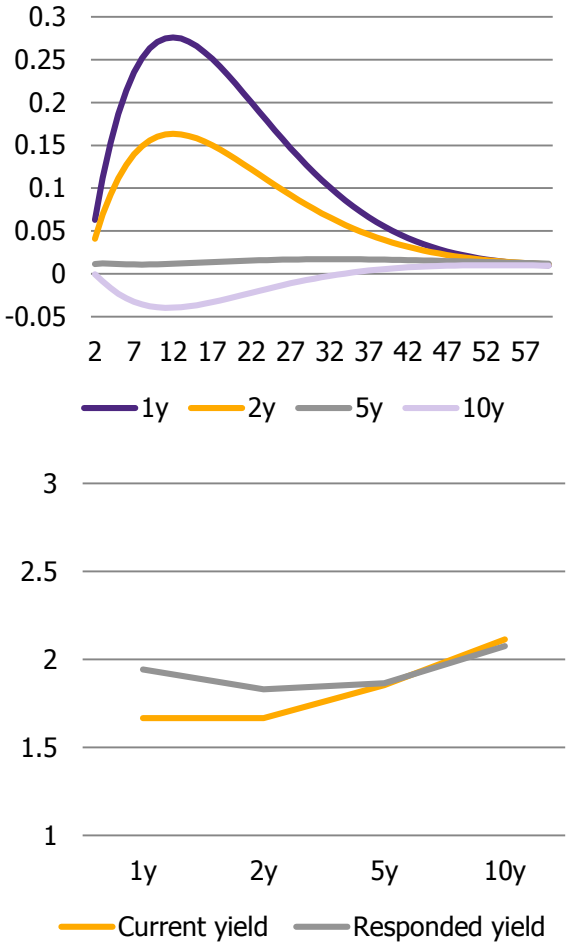
Correlation
0.1

2.1 Global Factor: Commodity Shock

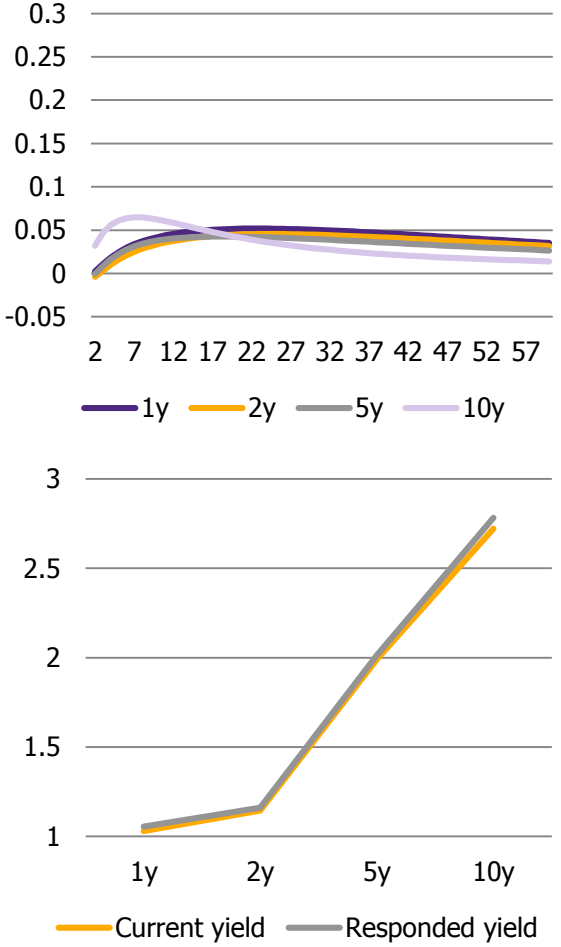
Thailand: Commodity shock



Korea: Commodity Shock

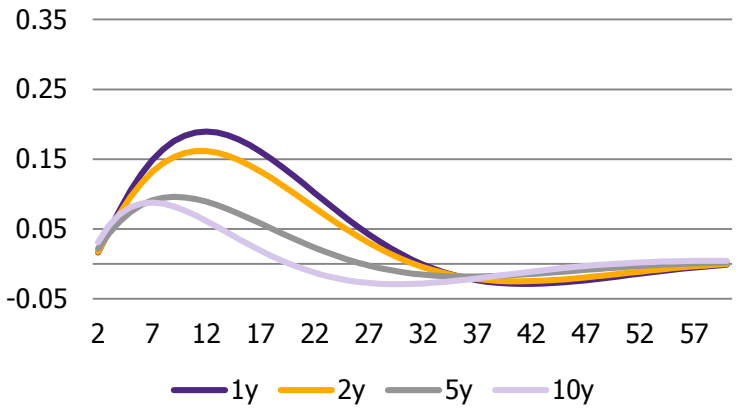


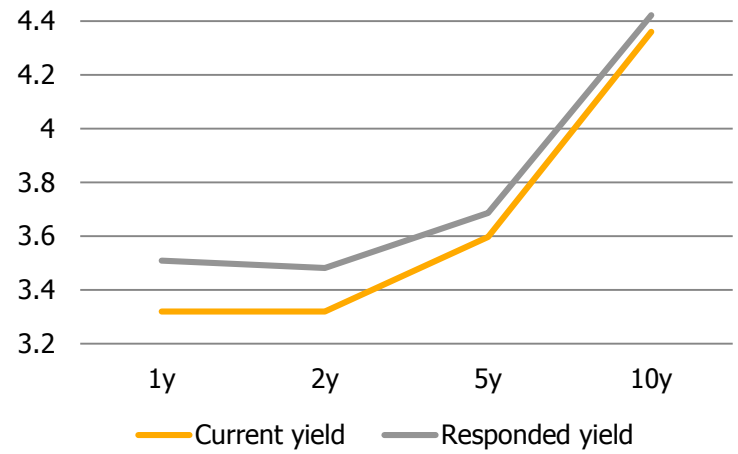
Singapore: Commodity Shock



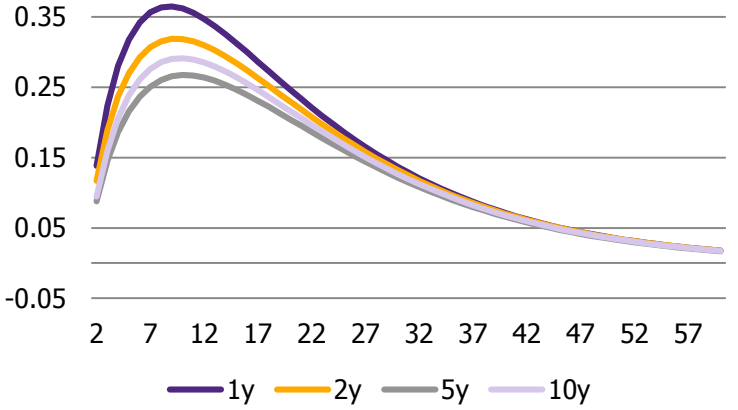
2.1 Global Factor: Commodity Shock

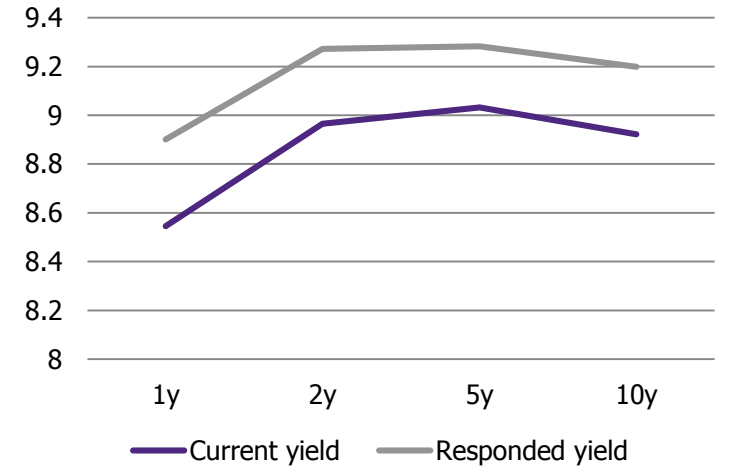
Malaysia: Commodity Shock





Indonesia: Commodity Shock





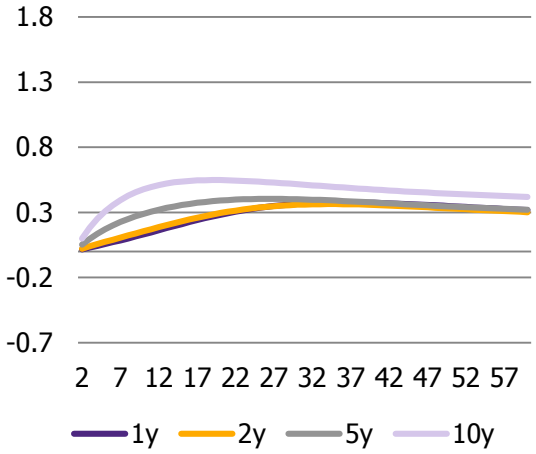
2.1 Global Factor: Commodity Shock

- A unit shock in commodity price causes yield curve to shift upward.
  The slope is "bear-flattened".
  - The responses are largest in Indonesia
  - The responses returns to their original level and die down almost completely
- For a country that relies on commodity export, a soar in commodity price would eventually drive up inflation expectation as well.
  - Level factor (PC1) would adjust following the change in inflation expectation thus driving up yields curves.
- For a country that rely less on commodity price, e.g. Singapore, the impact is immaterialized.

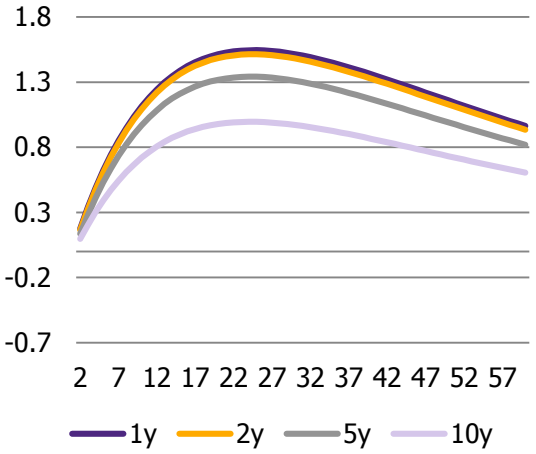
- Previous study such as Gibson et al. (2012) also concluded that the increase in world oil price will result in higher bond yields.

2.2 Global Factor: DM Policy Rate Shock

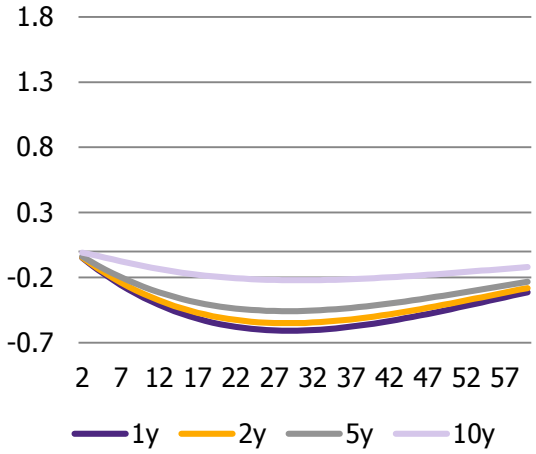
Thailand: DM Policy shock

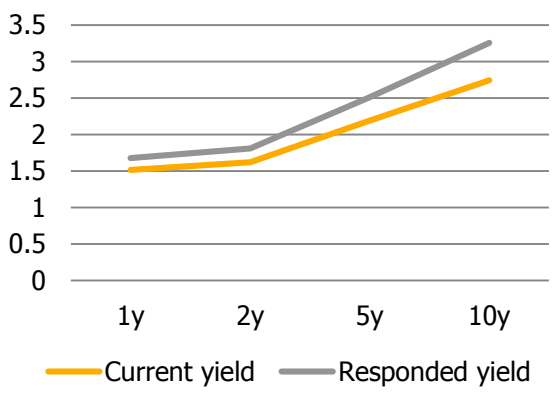


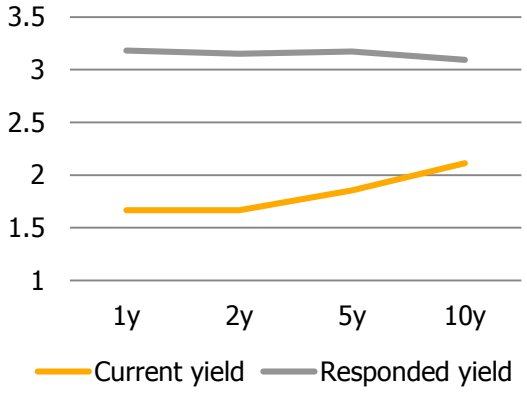
Korea: DM Policy Shock

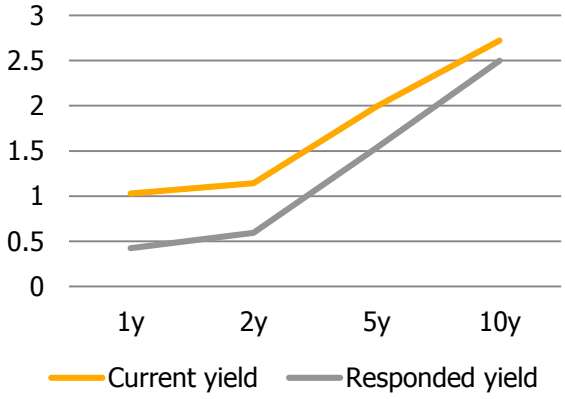


Singapore: DM Policy Shock









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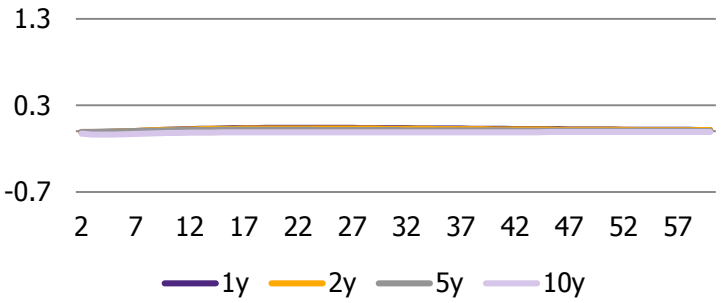
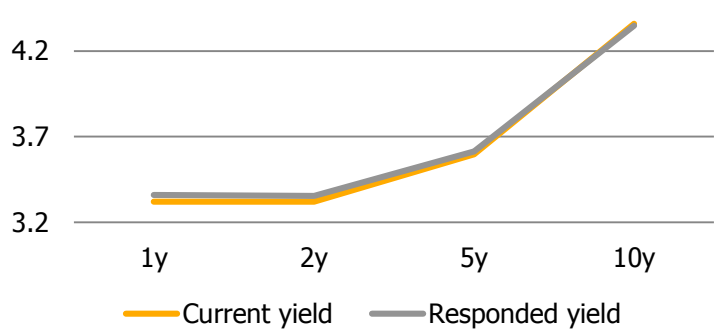
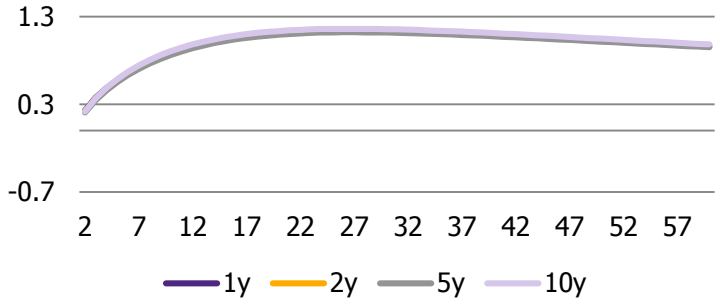
2.2 Global Factor: DM Policy Rate Shock

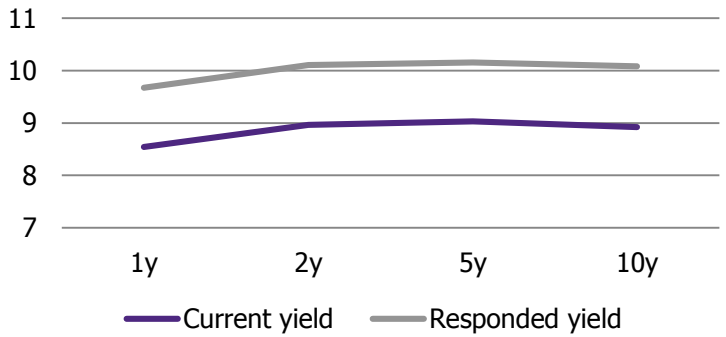
Malaysia: DM Policy Shock



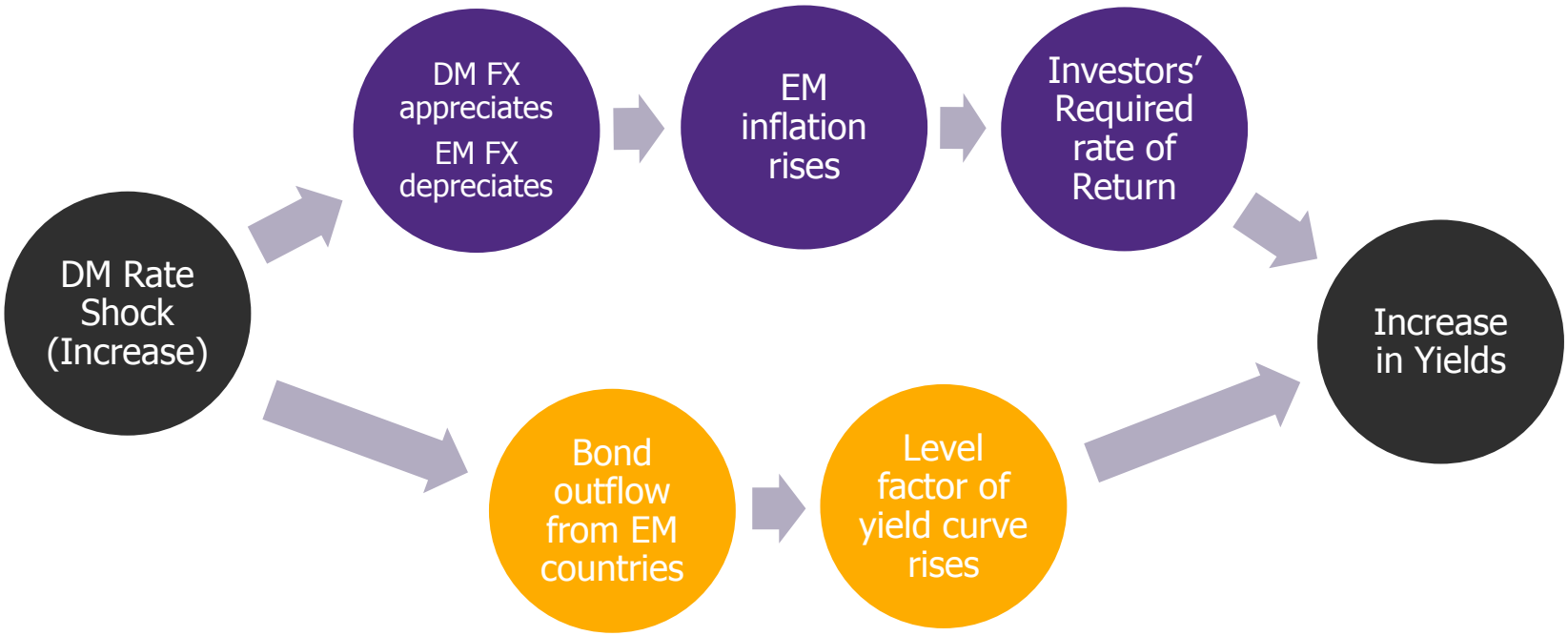


Indonesia: DM Policy Shock





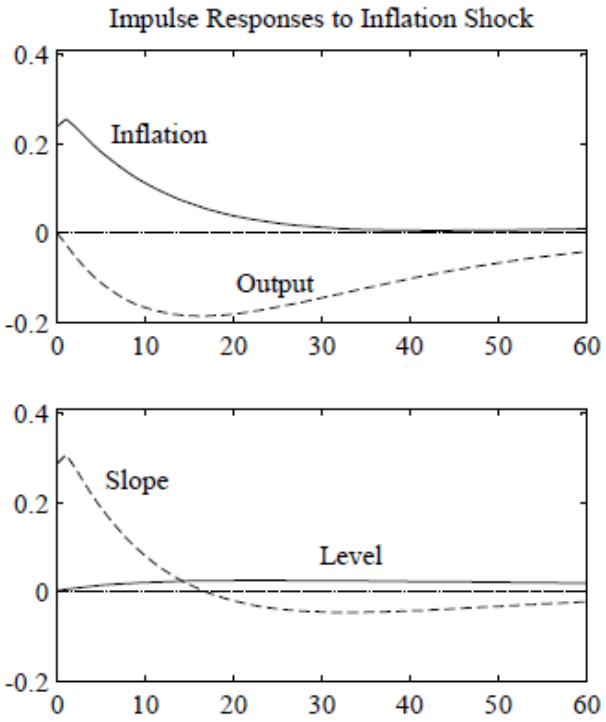
2.2 Impacts from DM interest rate shock



2.2 Global Factor: DM Policy Rate Shock

- A hike in DM policy rate would make their currency appreciated against EM countries (assume no equilibrium adjustment, or IRP)
  - According to PPP, appreciated currency would face a lower inflation.
  - On the other hand, EM countries that see their currency relatively cheaper will face a higher inflation
- Level factor of (PC1) which associated with the medium-term inflation expectation will be higher. Therefore, we experience that EM yields moving upward
- Yields do not return to their original level because change in relative price level boosts the perception of underlying inflation target

- This is in line with the finding from Rudebusch, and Wu (2008)



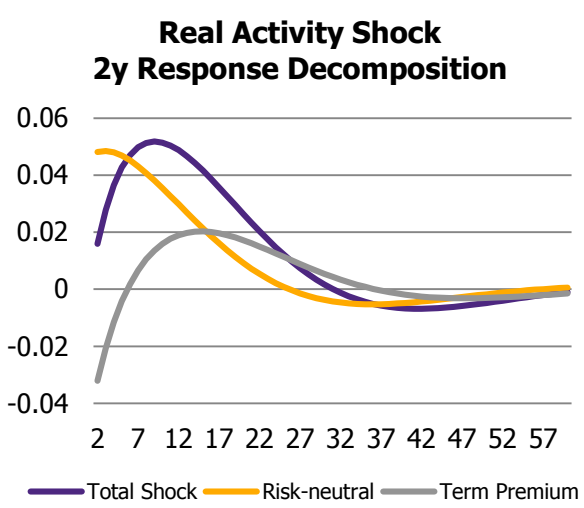
Conclusion

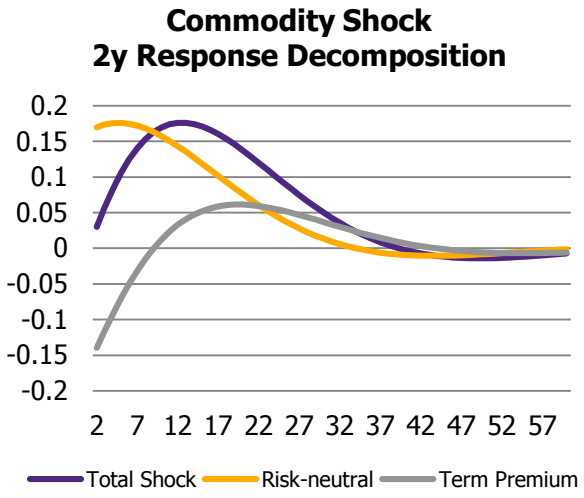
- **Both yield curve factors and macroeconomic factors help explaining dynamics of term structure**
  - **Positive domestic shock** result in an upward shift of yields (excluding Indonesia)
  - **Commodity shock** causes yield curves to shift upward, most of which bear-flatten
  - **DM policy rate shock** causes yield curves to shift up (excluding Singapore)
- **Evidence of yields co-movement**
  - **Commodity price:** co-movement in Thailand's and Malaysia's 10-year yields
  - **DM policy rate:** co-movement in Korea's and Indonesia's 10-year yields
  - The co-movement exist mostly through term premium channel, investors' **perception of risk**
- **Implications:**
  - **Investors** should diversify their portfolios to alleviate the impacts of external shocks
  - **Central banks** should monitor both domestic and external risk factors to ensure stability in asset markets

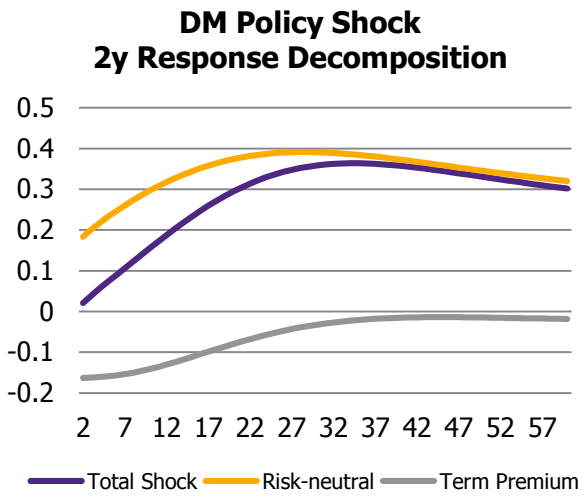
Thank you

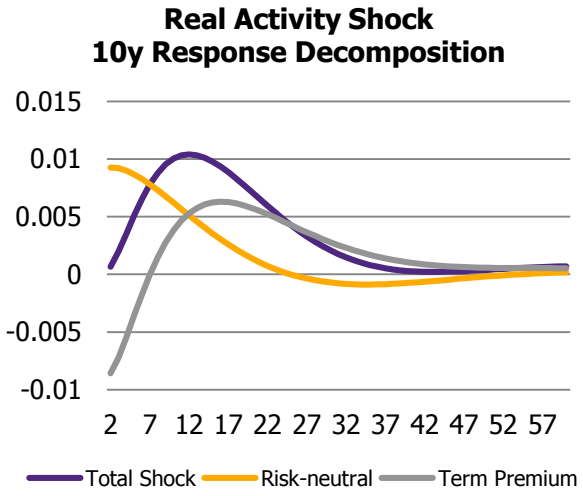
Appendix:
Channel Analysis

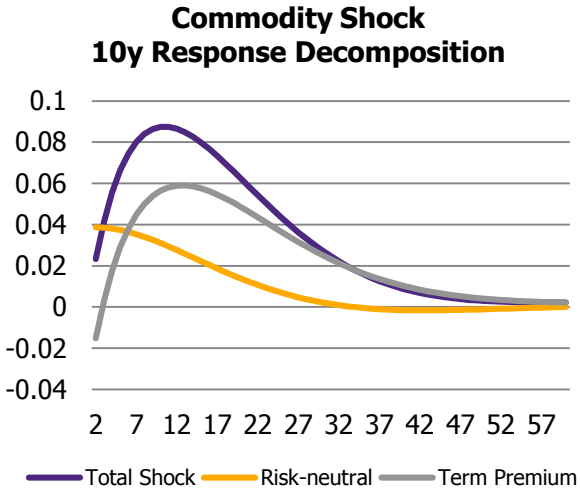
Thailand: Term Structure Decomposition

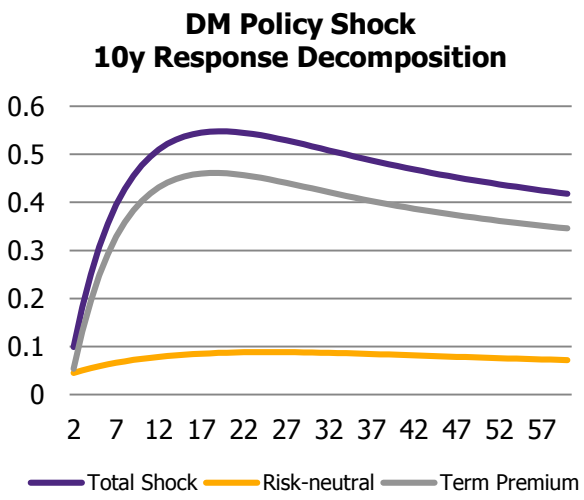












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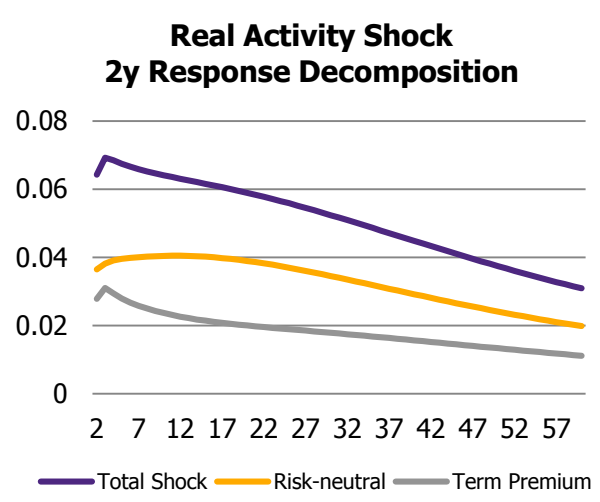
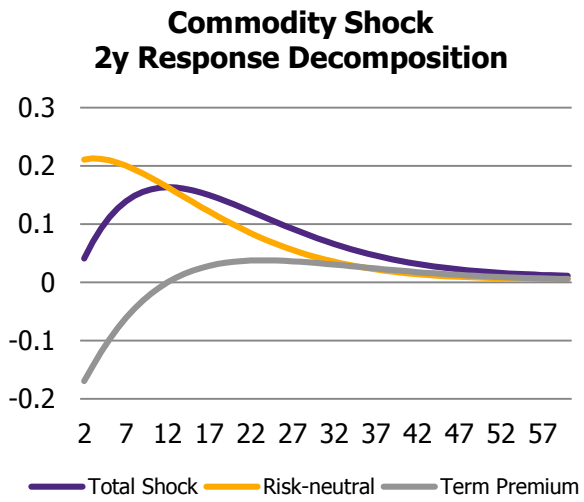
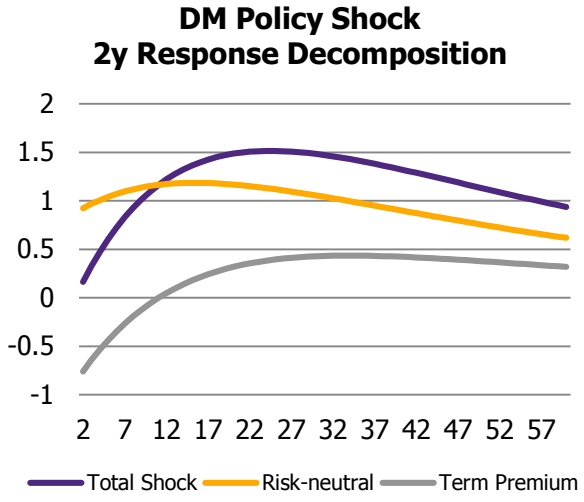
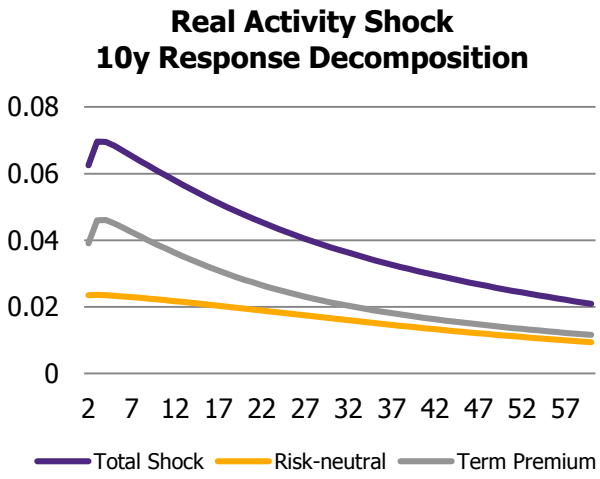
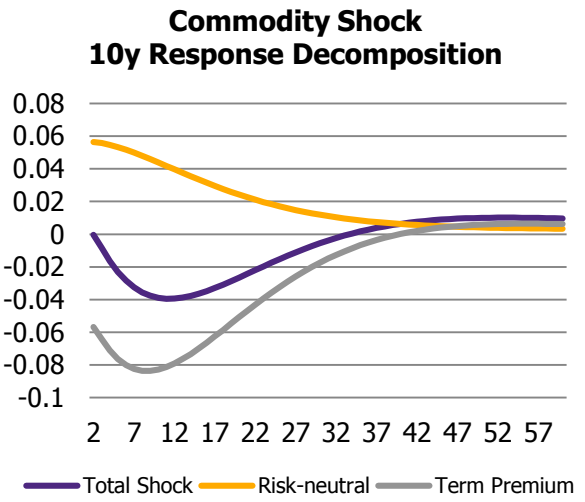
Korea: Impulse Response Decomposition

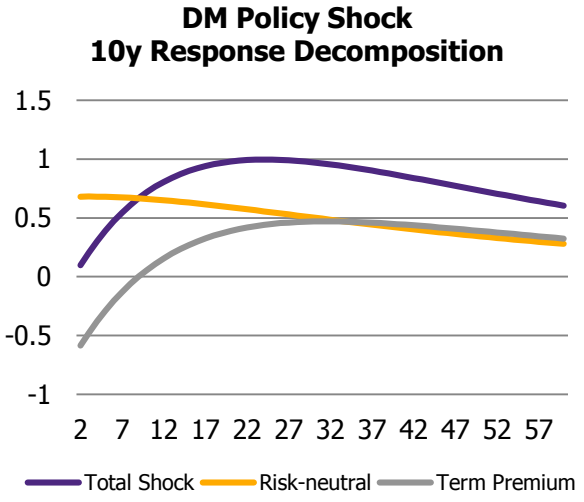












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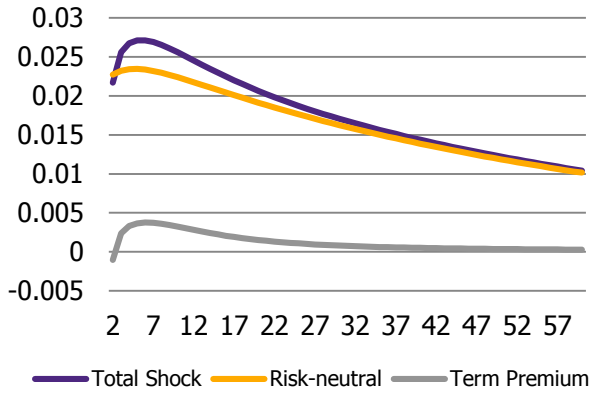
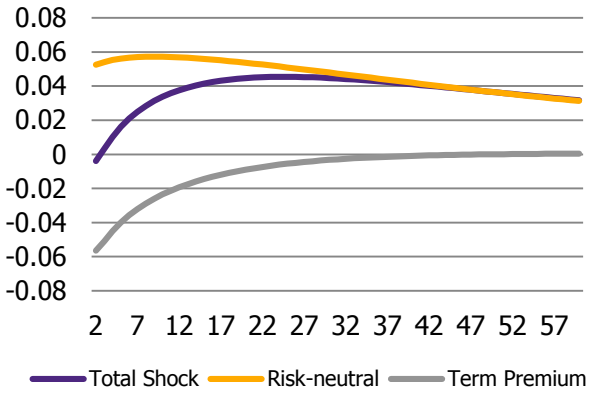
Singapore: Impulse Response Decomposition

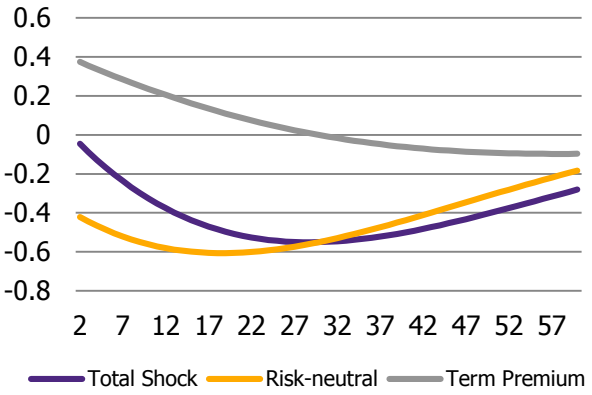
Real Activity Shock
2y Response Decomposition



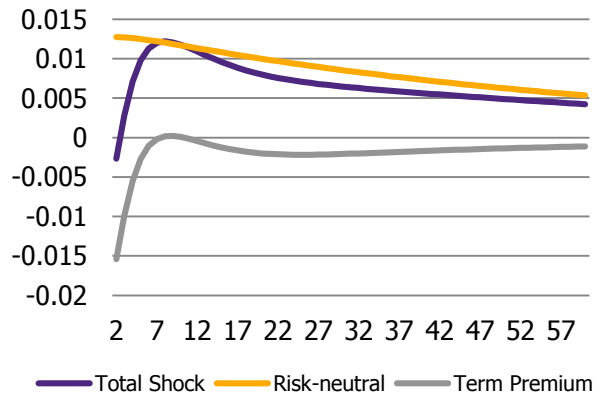
Commodity Shock
2y Response Decomposition



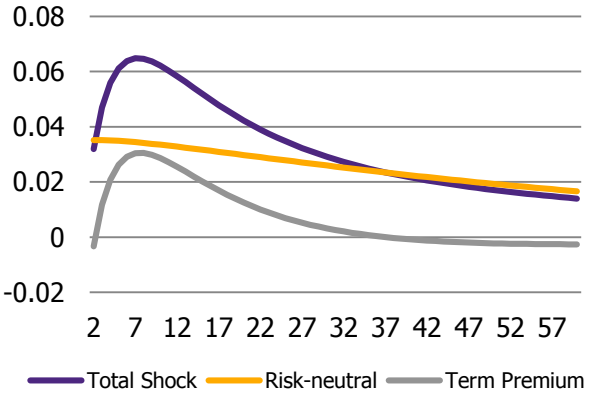
DM Policy Shock
2y Response Decomposition



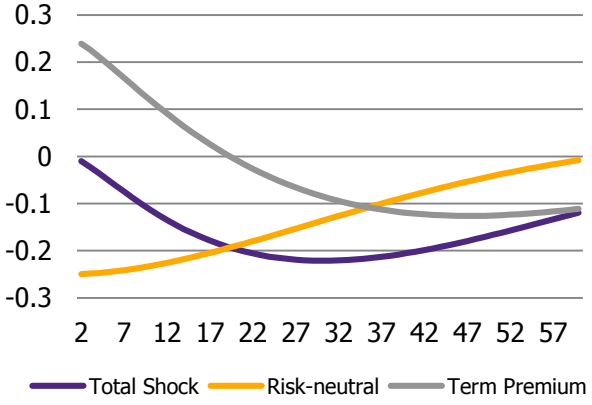
Real Activity Shock
10y Response Decomposition



Commodity Shock
10y Response Decomposition

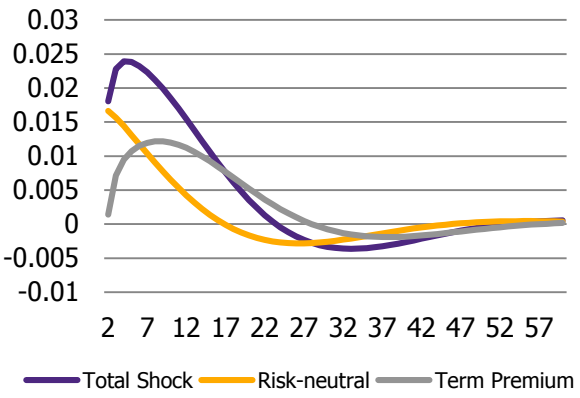


DM Policy Shock
10y Response Decomposition

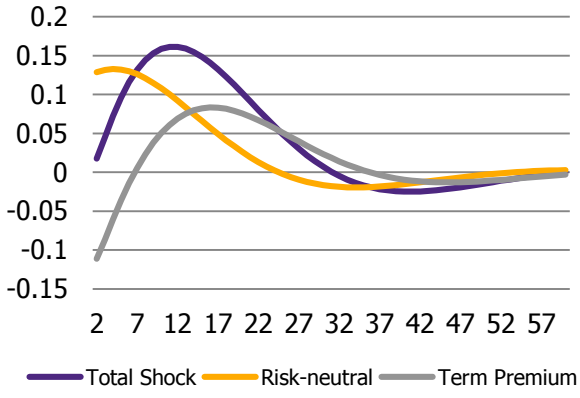


Malaysia: Impulse Response Decomposition

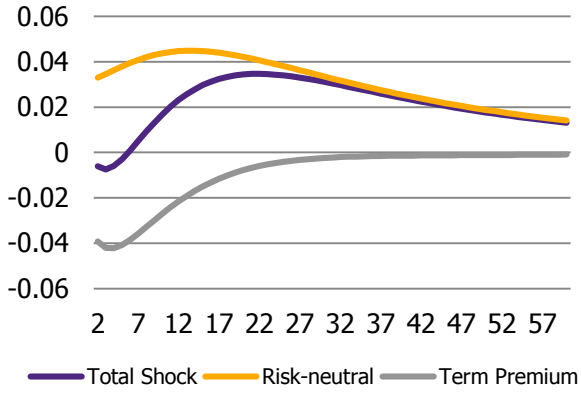
Real Activity Shock
2y Response Decomposition



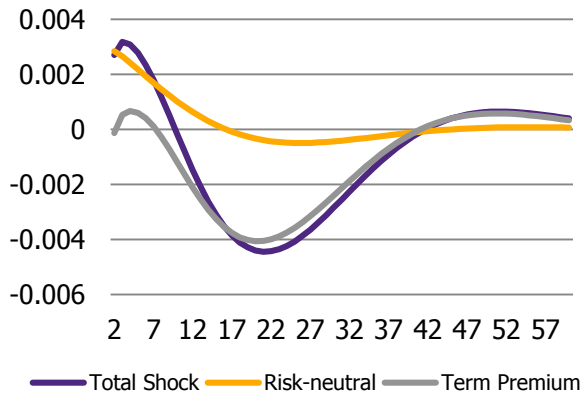
Commodity Shock
2y Response Decomposition



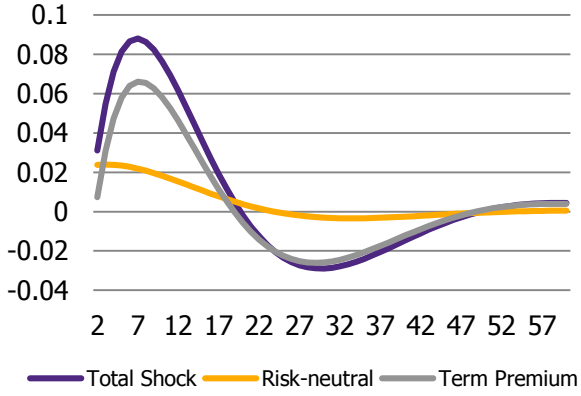
DM Policy Shock
2y Response Decomposition



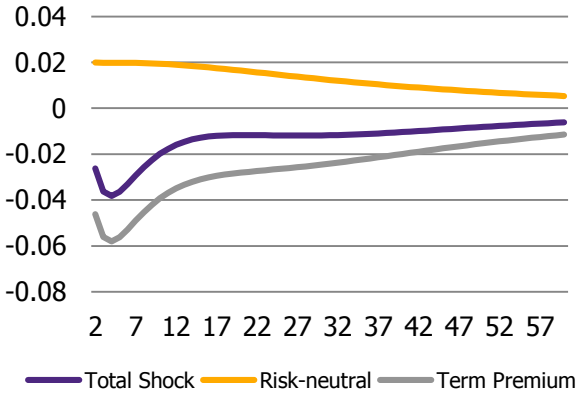
Real Activity Shock
10y Response Decomposition



Commodity Shock
10y Response Decomposition



DM Policy Shock
10y Response Decomposition



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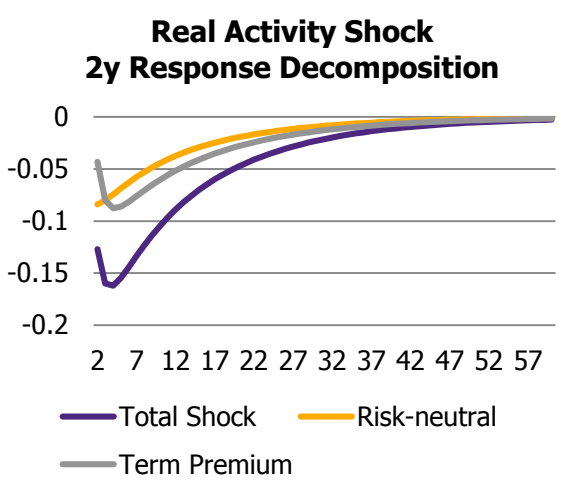
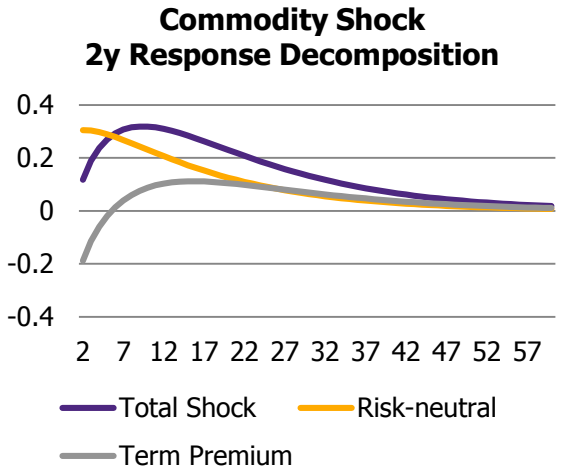
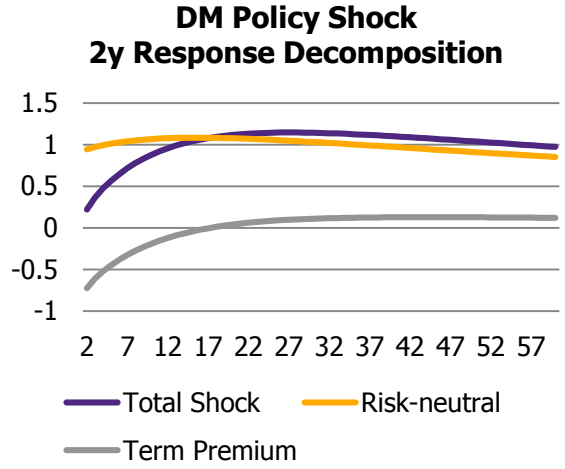
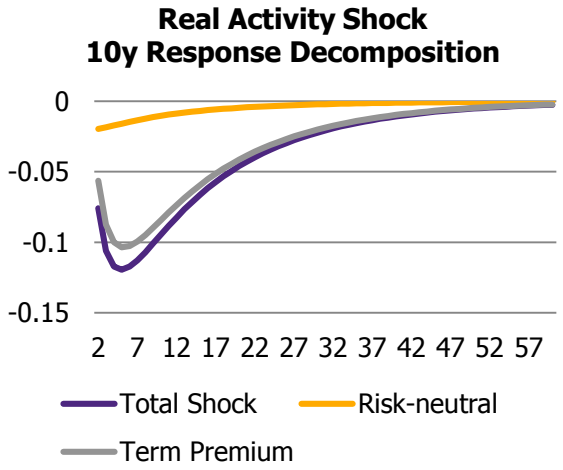
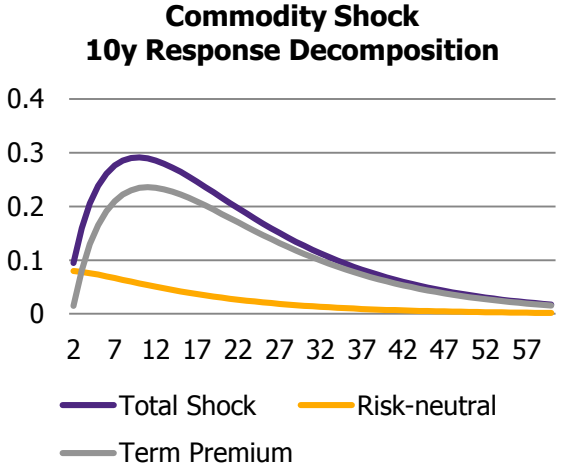
Indonesia: Impulse Response Decomposition

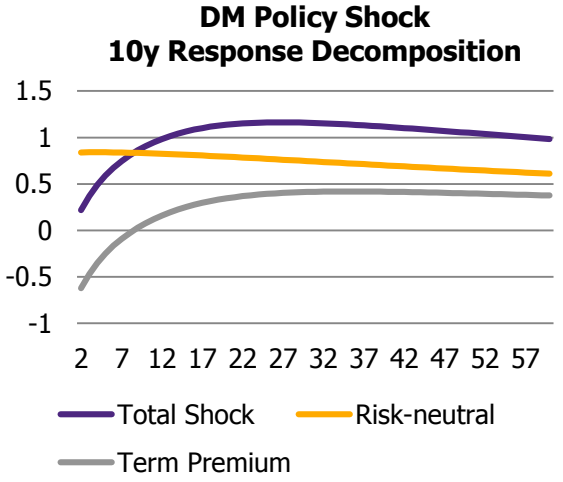












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