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Local Stress Index and Capital Flows at Risk in ASEAN-4 and Korea

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Local Stress Index and Capital Flows at Risk in ASEAN-4 and Korea

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Abstract

This paper quantifies the likelihood of spillovers to emerging ASEAN-4 economies (Indonesia, Malaysia, Philippines and Thailand) and Korea from shifts in US monetary policy, given the increasing hawkish rhetoric by the Fed to rein in strong US inflation. Using a newly constructed local stress index (LSI) to capture stress levels in the local currency-denominated sovereign bond and currencies markets, and applying the Capital Flows at Risk (CfaR) methodology, it is found that the spillovers to local market stress and the attendant risk of capital outflows in ASEAN-4 and Korea are non-trivial. The estimated LSI suggests that strains have emerged in local bond and currencies markets on more aggressive US Fed tightening policy. The level of stress is comparable to the previous stress episode in August 2015 when China announced changes to the RMB/USD central parity rate. Counterfactual analysis using the CfaR framework suggests that shocks to 10-year US real rates would sharply increase the probability and magnitude of non-resident portfolio capital outflows from the region over a six-month horizon.

JEL classification: C32, E44, E52, F32, G15,

Keywords: ASEAN-4, Korea, emerging markets, COVID-19, capital flows, financial stress, spillovers, real rates, term premia

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Abbreviations

ACM model	Adrian, Crump and Moench Model
ASEAN-4	Indonesia, Malaysia, the Philippines, and Thailand
BEKK model	Baba–Engle–Kraft–Kroner Model
CfaR	Capital Flows at Risk
COVID-19	Coronavirus Disease
DXY	US dollar Index
EMs	Emerging Markets
US Fed	US Federal Reserve
FCI	Financial Conditions Index
FX	Foreign Exchange
GFC	Global Financial Crisis 2008-09
IMF	International Monetary Fund
LSI	Local Stress Index
OLS	Ordinary Least Squares
PBC	People's Bank of China
PCA	Principal Component Analysis
PDF	Probability Density Function
Regional EMs	ASEAN-4 and Korea
RMB	Chinese Renminbi
UST	US Treasuries
VIX	Chicago Board Options Exchange's S&P500 index options

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I. Introduction

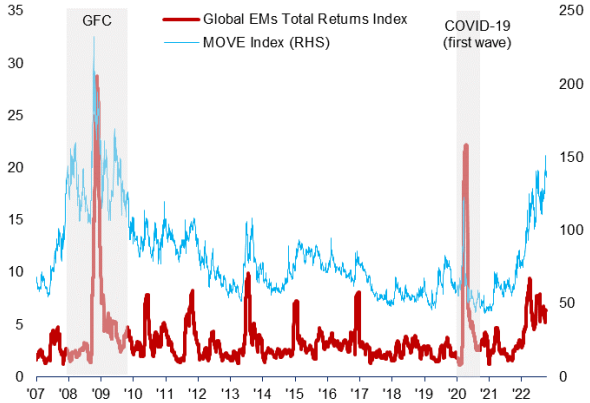
1. **Persistent high inflation in the United States and Europe has prompted respective central banks to respond more forcefully to rein in price pressures.** In the United States, the Federal Reserve (Fed) has embarked on more aggressive monetary policy tightening since early this year, in an attempt to tame high inflation. In Europe, the European Central Bank has also recently started to tighten monetary policy to keep inflation in check, even as the deepening energy crisis is pushing the euro area into a recession (AMRO 2022).

2. **The hawkish moves by the US Fed have triggered a sharp re-pricing of risk assets**, fueling sell-offs across global markets as higher interest rates made the US dollar dearer, and the aggressive pace of monetary tightening created fears of a hard landing in the United States. Fears of a simultaneous economic slowdown in the United States and Europe have unsettled market participants, fueling financial market volatility, and boosting demand for the safe haven US dollar.

3. **A sharper-than-expected tightening of global financial conditions can have material spillovers to emerging markets (EMs), including those in the ASEAN+3 region.** The literature has widely documented the adverse spillover effects from US monetary policy surprises to EMs (Ahmed, Ozge, and Queralto 2021; IMF 2021). US monetary policy surprises—referred to here as unexpected positive changes in the federal funds rate with respect to the consensus forecast prior to the Federal Open Market Committee (FOMC) meetings, tend to immediately lift long-term interest rates (i.e., 10-year domestic government bond yields) in EMs. This is typically accompanied by EM portfolio capital outflows and currency depreciation (Engler and others 2021). From mid-2021 to early 2022, US Treasury bond market volatility increased significantly (Figure 1), reflective of persistent upward surprises in US inflation. The uncertainties over the inflation outlook were reflected in higher inflation risk premium, which partly led to the upward drift in inflation breakevens (Figure 2). This has spilled over to EM bond markets, resulting in higher borrowing costs for EM governments.

Figure 1. United States and Global EMs: Bond Market Volatility

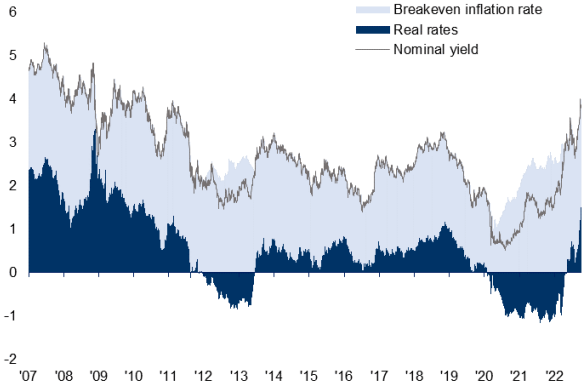
(Index)



Source: Haver Analytics; Bloomberg.
Note: The Merrill Lynch Option Volatility Expectations or MOVE is an index measure of US Treasury yield volatility. Figure is based on 3-month over-the-counter implied yield volatility. The volatility measure for global EMs refers to the 30-day volatility of the Bloomberg Emerging Markets USD-denominated aggregate returns index.

Figure 2. 10-Year US Treasury Nominal, Real, and Breakeven Inflation Rates

(In percent)



Source: Haver Analytics.
Note: The breakeven inflation rate is the difference between the nominal yield on a fixed-rate investment (e.g., Treasury security), and the real yield measured on an inflation-linked investment (e.g., Treasury Inflation-Protected Security of similar maturity.

4. **This paper examines the implications of a more aggressive US monetary policy tightening on financial stress and capital flows in ASEAN-4 and Korea (Regional EMs).**[2] While financial globalization has deepened cross border capital flows benefiting these Regional EMs, it has also amplified the transmission of global shocks, as seen during the Global Financial Crisis (GFC). Tightening financial conditions tend to precipitate acute market stress and sudden stops, as experienced during the Asian Financial Crisis where these Regional EMs were the most affected. This paper contributes to AMRO's surveillance toolkit in three ways.

- First, even without any material change to fundamentals, tightening global financial conditions can generate material spillover effects to EM bond yields through higher sovereign term premia (Kalemli-Ozcan 2019), ultimately resulting in higher cost of borrowing. We estimate the sovereign term premia to help policymakers to determine the relative sensitivity of sovereign risk to changes in global financial conditions. In turn, this information can be used to gauge the extent in which higher borrowing costs are driven by fundamentals or other factors (such as inflation risk premium).

- Second, we construct a new local stress index (LSI) à la IMF (2020b), which captures the stress levels (at a daily frequency) in the local currency-denominated sovereign bond market, and the currencies (FX) market in ASEAN-4 and Korea. The estimated sovereign term premium is used as one of the input variables in the LSI.

- Third, we use the International Monetary Fund (IMF) Capital Flows at Risk (CfaR) framework to gauge how the distribution of future capital flows in ASEAN-4 and Korea will be affected by changes in real interest rates in the US, controlling for various pull and push factors. The US real interest rate is captured by monetary policy stance (Fed policy) and financial conditions. The estimated LSI is used as one of the input variables for the CfaR. The spillover analysis is aimed at assessing the likelihood of capital flow reversals over the next six months.

5. **The paper is structured as follows.** Section II discusses sovereign term premia and their estimates for ASEAN-4 and Korea. Section III discusses the LSI and their estimates for ASEAN-4 and Korea. Section IV discusses the CfaR framework and applies it to ASEAN-4 and Korea. Section V concludes with a summary of the main messages.

II. Sovereign Term Premia

6. **While most central banks control short-term interest rates, aggregate demand tends to depend on longer-term interest rates (e.g., 10-year Treasury yields), where market expectations about future monetary policy comes into play**.[3] The yield on a bond reflects three components: (i) expected inflation; (ii) expected future short-term interest rates, i.e., the expected monetary policy stance; and (iii) a term premium, i.e., the added compensation demanded by lenders for bearing the risk of holding the longer-term asset. Information in the sovereign term premium captures the perceived riskiness of holding longer-term securities, although it is also influenced by changes in demand and supply for specific securities. For bondholders, one of the most important risks captured in the term premium is the risk from unexpected inflation. In essence, the sovereign term premium

[2] As a major emerging market, China is not included in this study due to data gaps/limitations.
[3] Engen, Laubach, and Reifschneider (2015).

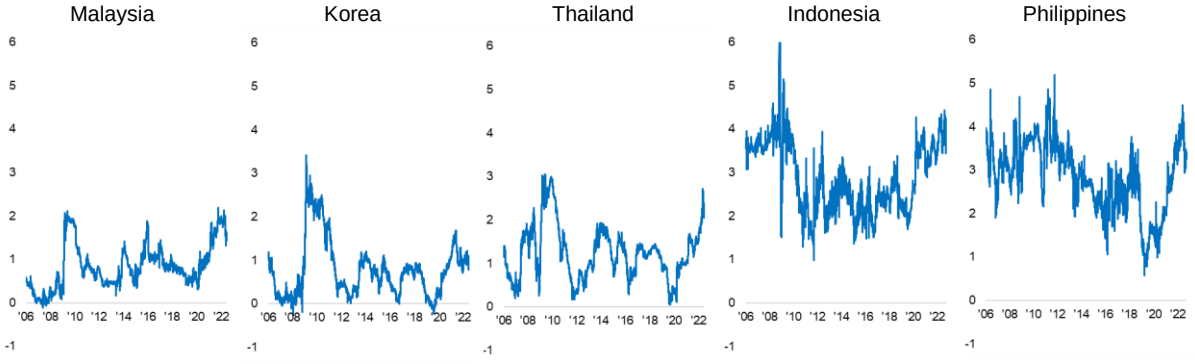
separates the expectations component of the borrowing cost (i.e., expected inflation and the expected nominal rate reflecting expected monetary policy), from the uncertainties of future inflation and other risks (e.g., credit risks).

7. **The term premium inherent in sovereign yields is useful to gauge the extent in which borrowing costs—particularly for longer-term securities— respond to monetary policy (or other macroeconomic outcomes, such as fiscal policy).** Assessing the behavior of the sovereign term premium over time is important in order to gauge whether borrowing costs respond "predictably" to local macroeconomic fundamentals (inflation, output, and the exchange rate) and domestic policy, or whether they are more correlated with global factors (such as US macroeconomic variables or global credit factors). This assessment would help to inform policy, as term premia that demonstrate a high correlation with global factors suggest that spillovers from global shocks to domestic borrowing costs would be non-trivial.

8. **There are various models and methods to capture the term premium in sovereign yields.** Although different models provide different point estimates of the term premium, they tend to agree on the general trend and dynamics. This study uses the so-called ACM model (Adrian, Crump, and Moench 2013) to estimate the term premia for ASEAN-4 and Korean sovereign bond yields.[4] See Annex I for estimation details.

9. **Estimates of the 10-year local currency sovereign term premia for ASEAN-4 and Korea increased during periods of heightened global risk aversion and country-specific risk events.** For example, in the Philippines, the rapid build-up of inflationary pressure in 2018, and more recently in 2022, coincided with the spike-up in the sovereign term premium (Figure 3). In Thailand, the political crisis in 2013-14 and, more recently, concerns about high inflation in 2022, coincided with the surge in the sovereign term premium. The average variability in the daily change of the sovereign term premium for aggregate ASEAN-4 and Korea post-GFC (from 2 January 2013 until 7 October 2022) is higher than in the pre-GFC period (1 July 2008 to 31 December 2009), underscoring the increased uncertainties in the recent global environment (Table 1).

Figure 3. ASEAN-4 and Korea: Estimated 10-Year Sovereign Term Premia
(In percent)



Source: Author's estimates.

[4] Literature shows that here are alternative models to estimate the term premia (e.g., Kim and Wright (KW) and Hördahl and Tristani (HT)). The ACM is most appealing, mainly because of its simplicity (both in terms of methodology and data inputs), thereby appropriate for this study.

Table 1. Standard Deviation of Daily Changes in Risk Neutral Yields and Term Premia

	Pre-GFC (2 Jan 2006 to 30 Jun 2008)		GFC (1 Jul 2008 to 31 Dec 2009)		Post-GFC (2 Jan 2013 to 7 Oct 2022)	
	Risk-Neutral Yield	Term Premium	Risk-Neutral Yield	Term Premium	Risk-Neutral Yield	Term Premium
Indonesia	1.2	0.1	1.5	0.8	1.3	0.7
Korea	0.4	0.3	1.3	1.0	0.6	0.4
Malaysia	0.4	0.2	0.8	0.7	0.6	0.4
Philippines	0.7	0.4	1.0	0.4	1.2	0.7
Thailand	0.7	0.5	1.0	0.8	0.6	0.4
ASEAN-4 and Korea	**0.7**	**0.3**	**1.1**	**0.7**	**0.9**	**0.5**

Source: Author's calculations.

III. Local Stress Index (LSI)

10. **The LSI allows close to real time monitoring of how changing global financial conditions translate into stress levels in (local-currency denominated) sovereign bond and currencies (FX) markets in ASEAN-4 and Korea.** The LSI focuses on several key indicators, chosen on an ex ante basis, given their information content in reflecting major stress events. As shown in Table 2, the indicators reflect local currency and bond market liquidity and stress conditions, unlike indicators used to derive broader financial condition indices, which are a reflection of funding costs for the broader economy.

Table 2. Variables in the LSI

Local-Currency Denominated Bond Market
• Bid-ask spread (10-year local currency sovereign bonds) • Term premia (10-year local currency sovereign bonds) • Realized volatility • Bond asset swap
Currencies (FX) Market
• Bid-ask spread • Implied volatility • Risk-reversal ratio • Forward points

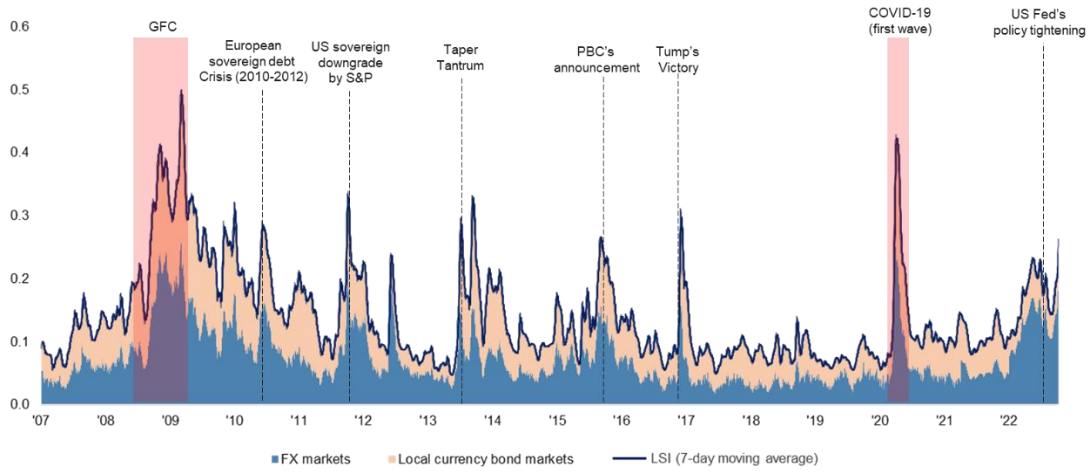
Source: Author's compilation.
Note: Currencies market refers to the bilateral exchange rates against the US dollar. Daily data are sourced from Bloomberg.

11. **The LSI, which captures the level of stress in the local currency-denominated bond and currencies markets in ASEAN-4 and Korea is constructed following the methodology in IMF (2020).** The index is unit-free and measured on an ordinal scale with range (0, 1]. In this respect, the interpretation of the LSI is simple, with a reading of one being the maximum stress level. See Annex II for details.

12. **The estimated LSI for ASEAN-4 and Korea captures key historical stress episodes coinciding with the tightening of global financial conditions.** Figure 4 shows that during the COVID-19 selloff in early 2020, the level of local market stress was significantly higher compared to earlier stress episodes, including the 2011 euro area sovereign debt crisis, the 2013 "taper tantrum," the 2015 People's Bank of China (PBC) announcement of the revision to their RMB/USD central parity rate, and the 2016 Trump presidential victory, although it was much lower compared to the GFC. It is interesting to note that unlike past episodes of stress, the level of market stress during COVID-19 (first wave), i.e., when initial daily new cases were rising with the subsequent declaration of a global pandemic by the World Health Organization in early 2020, normalized at a much faster pace. However, starting in early 2022, the stress level has been building up steadily.

The current stress level—which remains elevated—is comparable to the 2015 stress episode following the announcement by the PBC.

Figure 4. LSI: ASEAN-4 and Korea
(Index, 0 to 1; Reading of 1 being the maximum stress)



Source: Author's estimates.

13. **A large part of the underlying stress drivers originates from global financial market developments, particularly developments in the United States and euro area.** By examining the relative contributions of the bond market and the currencies market to the LSI for ASEAN-4 and Korea, we can identify the extent of spillovers from tightening of global financial conditions. The extent of the global spillovers to local bond and currency market stress in ASEAN-4 and Korea are estimated using time-varying conditional correlations between the Bloomberg US financial conditions index and the aggregate LSI.[5]

- **Bond market stress.** Until recently, an extended period of low global interest rates fueled sizeable inflows of foreign capital into Regional EMs. Those inflows were mostly in debt securities, in particular, local currency-denominated government debt instruments. As of June 2022, the total stock of foreign portfolio debt in ASEAN-4 and Korea amounted to USD739 billion (averaging 17 percent of annualized GDP).[6] With the turning of the tide, global interest rates are not only trending upwards, but they are rising at a faster pace compared to the past, with the United States leading the pack. During past episodes of global financial stress such as the GFC and the euro area debt crisis, the tightening of global financial conditions resulted in material spillovers to the bond market stress for ASEAN-4 and Korea. The susceptibility of Regional EM bond markets to global stress factors partly reflects the large foreign participation in their domestic bond markets (e.g., in Indonesia and Malaysia). Since early this year, spillovers to bond market stress in ASEAN-4 and Korea have noticeably increased, reflecting the more aggressive US Fed policy rate hikes (Figure 5(a)).

- **FX market stress.** With the US Fed embarking on an aggressive interest rate hiking cycle, interest rate differentials between Regional EMs and the United States are only

[5] The Bloomberg US Financial Conditions Index is one of the frequently cited indices to capture daily changes in global financial conditions. There are other indices, such as the National Financial Conditions Index (reported by the Chicago Fed), but available only at a weekly frequency. The empirical analysis is done using the so-called triangular Baba-Engel-Kraft-Kroner (BEKK) model.

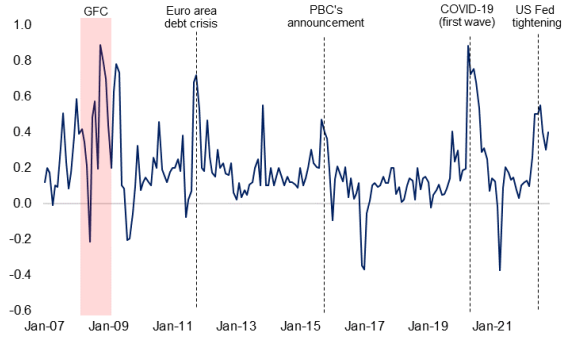
[6] The ratio to GDP ranges from 10 percent (in Thailand) to 26 percent (in Malaysia).

expected to widen. Coupled with the strong demand for the US dollar, Regional EM currencies have indeed come under increased depreciation pressure, including tightening of US dollar liquidity conditions in some economies. Spillovers from tightening global financial conditions to ASEAN-4 and Korea's FX market have been pronounced since early 2022, reflecting the more hawkish US Fed policy. As shown in Figure 5(b), the conditional correlation is larger in magnitude compared to the corresponding spillovers to the bond market. Similar trend can be observed in around mid-2015, where the stress level for ASEAN-4 and Korea was driven mostly by the currencies market.

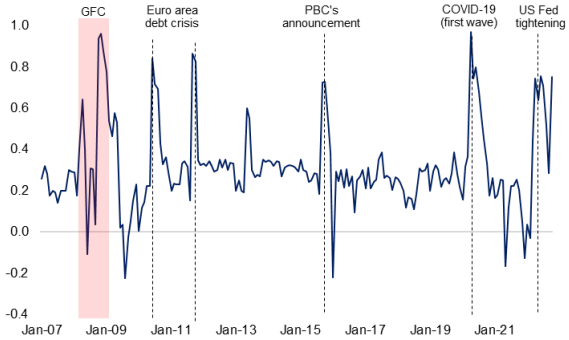
Figure 5. Spillovers from Changes in Global Financial Conditions to LSIs in ASEAN-4 and Korea

(Conditional correlation, –1 to +1)

(a) Spillover to Bond Market Stress



(b) Spillover to FX Market Stress



Source: Bloomberg; author's estimates.
Notes: Spillovers are estimated as the time-varying conditional correlation between the Bloomberg US financial conditions index (a proxy for global financial conditions) and the LSI. The value of the conditional correlation is between negative one and positive one, hence the spillovers are comparable between two variables and across time.

IV. Capital Flows at Risk (CfaR)

14. **The CfaR framework developed in the IMF can provide useful signals about risks to future capital flows, thus offering valuable information for macrofinancial surveillance** (Gelos and others 2019). The framework links macrofinancial conditions to the probability distribution of future capital flows. From the policymaking point of view, the analysis is useful for the assessment of tail risks and the likelihood of various risk scenarios for counterfactual analysis. Understanding the driving forces at the left tail of the distribution would also help policymakers to deal with severe downside risks.[7]

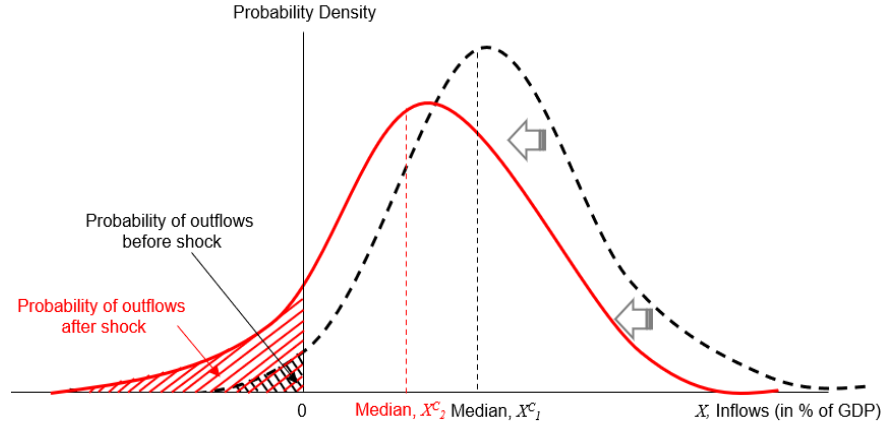
15. **The conceptual underpinning of the CfaR framework is as follows.**

- For illustrative purposes, the black dotted line in Figure 6 shows the distribution of estimated future capital flows for country *C* over the next *n* horizons. The mass of the density is skewed towards the right, indicating that at this initial stage, country *C* would largely see net capital inflows, with only a small probability of net ouflows (represented by the shaded area in black); the median level of net capital flows (in percent of GDP) is given by X_1^C. Now assume there is a large negative external shock. The probability distribution will shift leftwards, as shown by the red line, with

[7] The CfaR is not structural, and therefore cannot ascertain causal links. However, it is able to quantify the macroeconomic impact stemming from systemic risk events, making it possible to evaluate the severity of such risks. The CfaR, as a reduced-form set of equations, is most appropriate for comparative statics analysis, and is part of the IMF's multilateral surveillance toolkit (see Annex III).

the median level of net capital inflows now given by X_2^C. Under this new state, the probability density represented by the shaded area in red is now larger, indicating that the outlook for capital inflows has deteriorated after the shock.

Figure 6. Shifts in Predicted Capital Flows Density after a Shock



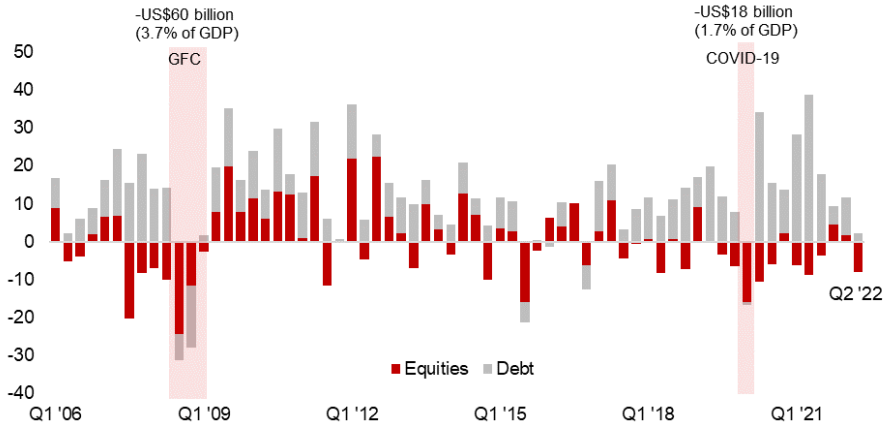
Source: Gelos and others (2019)

- The risk to capital flows can be quantified by: (i) calculating the probability that capital flows will fall below a certain threshold, e.g., zero, which distinguishes between inflows and outflows; or (ii) estimating the volume of outflows that would be reached with a given probability—referred to as "capital flows at risk," analogous to the concept of "value at risk" in the literature on financial risk management. It is common to quantify CfaR using the 5th percentile of the distribution; however, policymakers can use any threshold that is meaningful, such as the 10th percentile.

A Estimation of CfaR in ASEAN-4 and Korea

16. **This section estimates the distribution of future portfolio capital flows in ASEAN-4 and Korea as a function of domestic and global macroeconomic fundamentals and financial conditions.** In this exercise, we focus on non-resident portfolio flows (equities and debt securities), which matter most for financial stability in EMs (Obstfeld 2012) (Figure 7).

Figure 7. Historical Non-Resident (Net) Portfolio Capital Flows in ASEAN-4 and Korea
(USD billion)



Source: National authorities via Haver Analytic

17. **First, we estimate the future (six-month ahead) portfolio capital flows based on current macro-financial conditions using a quantile regression framework**. See Annex III for estimation details.

The quantile regression specification is as follows:

$$y_{t+h}^{q} = \alpha^{q} + \beta_{1}^{q} X_{1,t} + \beta_{2}^{q} X_{2,t} + \beta_{3}^{q} X_{3,t} + \beta_{4}^{q} X_{4,t} + \beta_{5}^{q} LSI_{t} + \varepsilon_{t+h}^{q}$$

where:

y_{t+h}^{q} refers to non-resident net portfolio capital flows into ASEAN-4 and Korea (in percent of GDP) *h* months ahead, $h \in \{1,2,\ldots,6\}$;

q refers to quantiles, $q \in \{0.10,\ 0.25,\ 0.50,\ 0.75,\ 0.90\}$;

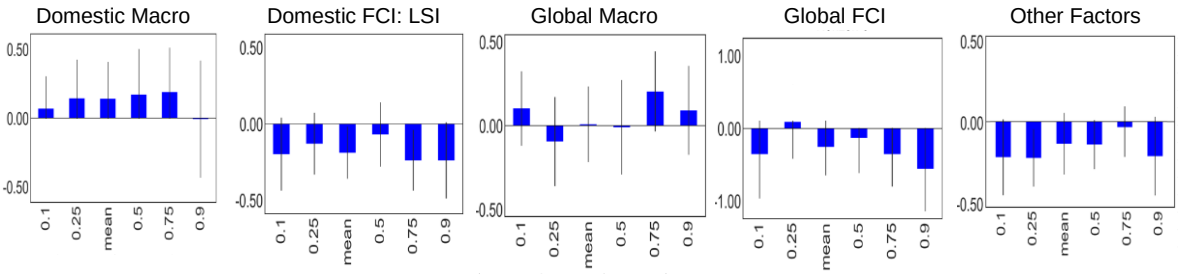
$X_{i,t}$ refers to a vector of variables, i = 1, …, 4; where $X_{1,t}$ are domestic macroeconomic fundamentals, $X_{2,t}$ are trading partners' macroeconomic fundamentals, $X_{3,t}$ is the global financial conditions index, and $X_{4,t}$ are other factors.

- The estimated LSI for ASEAN-4 and Korea (from Section III) is also added in the regression to capture financial conditions in the local currency-denominated sovereign bond and currencies markets. The estimated coefficients from the quantile regression show a positive relationship between domestic fundamentals—commonly known as pull factors in the literature—and capital flows in ASEAN-4 and Korea, i.e., higher real GDP growth in ASEAN-4 and Korea is associated with a larger volume of capital flows into these EMs. The coefficients are statistically significant across most quantiles.

- In contrast, tighter financial conditions (both at home and abroad) tend to have a negative relationship with capital flows, which is intuitive. Figure 8 (second and fourth panels) shows that as financial conditions tighten, the volume of capital inflows is weaker, the results of which are statistically significant in larger quantiles.

- In line with the empirical literature, greater external vulnerabilities (from higher foreign participation in domestic debt markets and/or a higher ratio of short-term debt to reserves) are associated with weaker volume of capital inflows (Figure 8, last panel).

Figure 8. Quantile Regression Coefficient Estimates
(Normalized coefficients, 6-month horizon)

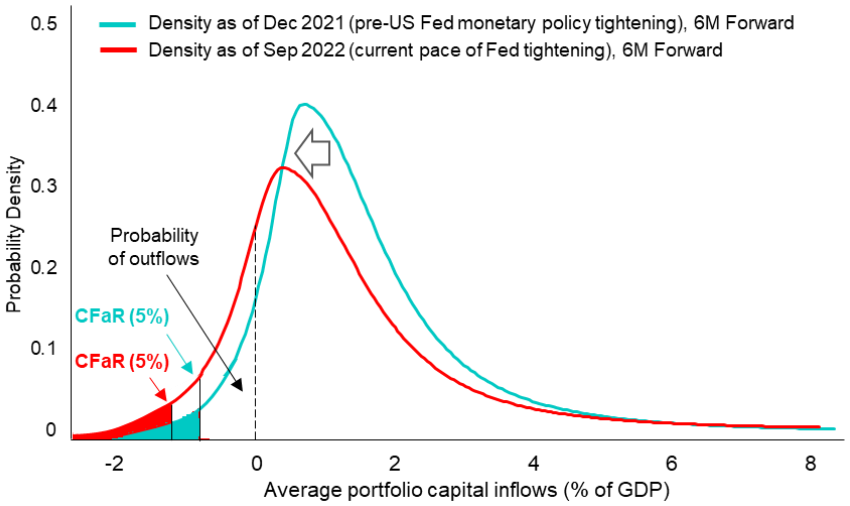


Source: Author's estimates

18. **Second, the coefficient estimates for the range of percentiles (from 10th to the 90th) are then used to construct the conditional forecast of the entire distribution of portfolio capital flows.** Following IMF (2020a), the average of the coefficients from the regressions for the 5th to 30th percentile reflects the impact of a variable on the lower tail of the predicted distribution—the focus of this exercise. The risk to capital flows can be identified by examining the lower tail of the distribution and quantifying the volume of capital flows that would reach (or exceed) a certain given probability—typically 5 percent. This amount is the estimated CfaR at the 5 percent level.

19. **The results of the estimated CfaR for ASEAN-4 and Korea suggest that the short-term outlook (six months ahead) for non-resident portfolio capital flows has turned weaker compared to end-2021.** The green curve in Figure 9 shows the predicted probability density of non-resident portfolio capital flows six months forward based on information up to December 2021, i.e., before the US Fed embarked on the rate hiking cycle. The average volume of capital inflows, i.e., the conditional mean of the distribution, was estimated at +1.4 percent of GDP. However, by September 2022, the mode of the distribution had shifted to the left (as indicated by the solid red curve), suggesting that tightening global financial conditions are indeed weighing on the outlook ahead, with the probability of capital flow reversals increasing from 14 percent (as of December 2021) to almost 20 percent (as of September 2022). Using the 5 percent CfaR threshold, the magnitude of capital outflows in September 2022 is forecast, on average, to be at least 1.1 percent of GDP (up from at least 0.7 percent of GDP in December 2021) (Table 3).

Figure 9. ASEAN-4 and Korea: Estimated Forecast Densities of Non-Resident Portfolio Capital Flows (December 2021 versus September 2022)



Source: Author's estimates

Table 3. Estimated CfaR

Period	Probability of Capital Flow Reversal (%)	CfaR (5%)	CfaR (10%)
		% of GDP	
Pre-COVID-19, first wave (Dec 2019)	46	-2.1	-1.6
Pre-US monetary policy tightening (Dec 2021)	14	-0.7	-0.2
US monetary policy tightening (Sep 2022)	20	-1.1	-0.4

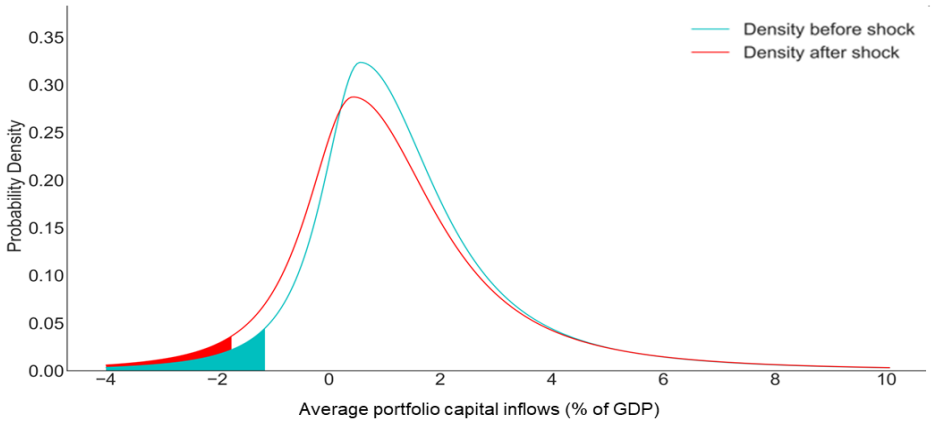
Source: Author's estimates

B Counterfactual Analysis: Impact of a Shock to the 10-Year US Treasury Real Rate

20. **Given market expectations that the Fed's rate hiking cycle has yet to run its course, US real yields have steadily climbed higher, putting pressure on sovereign borrowing costs** (see Figure 4). When US bond yields rise is driven by real rates instead of inflation expectations, it typically leads to an underperformance of ASEAN-4 and Korean assets and capital outflows from these markets (Pande 2021).

21. **Our estimates show that a sharp increase in US real yields is associated with larger probability of capital outflows from ASEAN-4 and Korea.** Assuming a spike-up in US real rates corresponding to a two-standard deviation increase (about 150 basis points), the tail risk (i.e. 5 percent CfaR) to ASEAN-4 and Korea's non-resident portfolio capital flows is estimated at about 2 percent of GDP, on average, over the next six months. After the shock, the mode of the distribution clearly shifts leftwards, with an increase in the probability of a capital flow reversal six months forward (from 20 to 30 percent). In the absence of policy countermeasures, the estimated tail risk (5 percent) is an outflow of at least 2 percent of GDP, on average, over the next six months (whereas the corresponding CfaR before the shock was –1.1 percent of GDP) (Figure 10).

Figure 10. ASEAN-4 and Korea: Forecast Densities of Non-Resident Portfolio Capital Flows (Before and After a Shock to the 10-Year US Treasury Real Rate)



Source: Author's estimates
Note: The analysis assumes no policy countermeasures.

V. Conclusion

22. **This paper introduces two new analytical tools for AMRO surveillance: an index for measuring stress in local currency and bond markets, and a framework for monitoring capital flow risks.** Constructed on a daily frequency, the LSI can be used to gauge—almost in real time—local market liquidity and stress conditions, and thereby help to inform policy. The CfaR framework links macrofinancial conditions to the probability distribution of future capital flows. With timely monitoring of macro-financial conditions—especially during stress periods—the CfaR framework allows policymakers to quantify, monitor and manage capital flow risks.

23. **The LSI and the CfaR framework offer promising areas for further work.** The LSI can be extended to include bilateral swap lines. Further work on the CfaR could examine the interaction of fiscal policies with the global financial conditions index on different types of capital flows (e.g., bank lending and foreign direct investment). The framework could also usefully be applied to bilateral capital flows data to understand how downside risks differ across source and destination countries.

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Annex I

Estimating Sovereign Term Premia for ASEAN-4 and Korea

Sovereign term premia for ASEAN-4 and Korea are estimated using the so-called ACM model (Adrian, Crump, and Moench 2013). This term structure is based on the principal assumption that bonds are priced in a way that precludes arbitrage opportunities across maturities, i.e., pricing is assumed to make it impossible to form a portfolio consisting of bonds with different maturities that generates a riskless profit (Cohen, Hördahl, and Xia 2018).

Prior to running the ACM model, it is necessary to construct a term structure of bonds yields across different maturities for each of the five economies (see table below). Using a daily frequency from 2 January 2007 to 10 October 2022, the historical term structure is constructed for the following yield curve maturity points: 3M, 6M, 1Y, 2Y, 3Y, 5Y, 10Y, 15Y, 20Y and 30Y.

Description of Variables

Indicator	Economies	Unit	Sources
Local currency-denominated sovereign bond yields across the term structure: • 3M, 6M Treasury bills • 1Y, 2Y, 3Y, 5Y, 10Y, 15Y 20Y, 25Y and 30Y Treasury bonds	• Indonesia	%	Bloomberg and CEIC
	• Korea		Bloomberg
	• Malaysia		Bloomberg
	• Philippines		Bloomberg
	• Thailand		Bloomberg and CEIC

Source: Author's compilation

Next, we employ principal component analysis (PCA) and ordinary least squares (OLS) regression to extract the term premium from the yield curve. This is done in three steps.

(1) First, we estimate the factor model from the PCA of the observed yields from the term structure.[8] The estimated residuals, $\hat{V}$, and residual covariance, $\hat{\Sigma}$, are then retrieved.

(2) Second, we estimate the following equation using OLS:

$$x = a + cZ + \beta'\hat{V} + e$$

where yield (or returns), x, are regressed on a constant, a; lagged factors (or state variables), Z; and the estimated shock component collected from the vector autoregression, $\hat{V}$; e is the matrix of residuals. Put simply, the return series is the sum of expected returns, return innovations and an error term.

(3) Finally, we estimate the price of risk which is a function of the residual covariance between (excess) returns across the different maturities. The price of risk is then set to zero in order to generate the risk-neutral yield curve. The term premium is computed as the difference between the model-implied fitted yield (which tends to be very close to the actual data) and the risk-neutral yield.

[8] Each yield curve depends on a set of factors (either macro-factors or some implied state variables), which can be adequately modeled using a simple first-order vector autoregression. Typically at least three principal factors (of a total five factors) are required to fit the model.

Annex II

Constructing the LSI for ASEAN-4 and Korea

A new local stress index (LSI) capturing the level of stress in the local currency-denominated bond and currency markets in ASEAN-4 and Korea is constructed à la IMF (2020b), following the index construction methodology of Hollo, Kremer and Lo Duca (2012) and Garcia-de-Andoain and Kremer (2018).

First, the daily indicators, from 2 January 2007 to 10 October 2022, are chosen ex ante, focusing on the indicators that have low correlation in peacetime/normal market functioning but can become increasingly correlated at times of stress (see table below). Each variable is transformed in a way that ensures a homogenous distribution and scale by applying the probability integral transform to a cumulative distribution function. The transformed variable is unit-free and measured on an ordinal scale with range (0, 1].

Second, using the BEKK model (Engler and Kroner 1990), a matrix of time-varying conditional corrections between the transformed variables, C_t, are estimated:

$$C_t = \begin{pmatrix} 1 & \rho_{21,t} & \rho_{31,t} & \cdots & \rho_{81,t} \\ \rho_{12,t} & 1 & \rho_{32,t} & \cdots & \rho_{82,t} \\ \rho_{13,t} & \rho_{23,t} & 1 & \cdots & \rho_{83,t} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho_{18,t} & \rho_{28,t} & \rho_{38,t} & \cdots & 1 \end{pmatrix}$$

Third, using matrix multiplication, the country level LSI for each of the five economies is computed using the following formula:

$$LSI_t^C = (w\ o\ z_t)C_t(w\ o\ z_t)'$$

where w is a vector of indicator weights, z_t is the vector of transformed variables, $(w\ o\ z_t)$ is the Hadamard-product (i.e., an element-by-element multiplication of the vector of subindex weights and the vector of transformed values at time t,, and C_t is a three-dimensional array of time-varying conditional correlation coefficients ρ_{ij} between variables i, j. The contributions of the bond market and FX market stress to the LSI are derived from the indicator weights. See Garcia-de-Andoain and Kremer (2018) for detailed technical discussion on the aggregation methodology.

Finally, for the computation of the aggregate LSI for ASEAN-4 and Korea ("regional" LSI), it is computed by taking the simple average of the individual LSIs, i.e., equal weighting is applied to the five individual LSIs.

Description of Variables

Indicators	Description	Unit	Sources
Bond Market			
Bid-ask spread (10-year local currency sovereign bonds)	Spread between bid and ask yield	Basis points	Bloomberg
Term premia (10-year local currency sovereign bonds)	Yield difference between longer-maturity bond and average expected short-term rate (estimated from Section II)	%	AMRO staff estimates
Realized volatility	Actual yield volatility (3M percentage yield changes)	%	Bloomberg
Bond asset swap	Fixed for floating rate derivative contract (3M-10Y swaption rate)	%	Bloomberg
Currencies (FX) Market			
Bid-ask spread	Spread between bid and ask spot price	Basis points	Bloomberg
Implied volatility	Expected volatility (3M at the money FX options)	%	Bloomberg
Risk-reversal ratio	Positions by market participants in the FX market (difference between the volatility of 25 delta out of the money FX Call and 25 delta out of the money FX Put options)	Basis points	Bloomberg
Forward points	A proxy for currency basis	Basis points	Bloomberg

Source: Author's compilation

Annex III

Estimating CfaR for ASEAN-4 and Korea

The CfaR for ASEAN-4 and Korea is estimated à la IMF (2019), the approach of which is similar to the concept of Growth-at-Risk developed in IMF (2017, 2018) (see also Prasad and others (2019)).

First, using PCA, the macro-financial variables are partitioned into meaningful groups (such as domestic macroeconomic fundamentals, trading partners' macroeeconomic fundamentals, domestic financial global financial conditions, etc.) (see table below). This process of dimension-reduction helps to improve the forecasting by extracting common trends in the chosen variables.

Second, using monthly data from January 2012 to September 2022, a quantile regression of the following specification is estimated for a range of percentiles, i.e., from the 10th to the 90th percentile.

$$y_{t+h}^{q} = \alpha^{q} + \beta_1^{q} X_{1,t} + \beta_2^{q} X_{2,t} + \beta_3^{q} X_{3,t} + \beta_4^{q} X_{4,t} + \beta_5^{q} LSI_t + \varepsilon_{t+h}^{q}$$

where:

y_{t+h}^{q} refers to aggregate non-resident portfolio capital flows into ASEAN-4 and Korea (in percent of GDP) *h* months ahead, $h \in \{1, 2, \ldots, 6\}$;

q refers to quantiles, $q \in \{0.10,\ 0.25,\ 0.50,\ 0.75,\ 0.90\}$;

$X_{i,t}$ refers to a vector of variables, i = 1, …, 4 representing the four partitions: (i) domestic macroeconomic fundamentals, $X_{1,t}$; (ii) trading partners' macroeconomic fundamentals, $X_{2,t}$; (iii) global financial conditions, $X_{3,t}$; and (iv) other factors, $X_{4,t}$; with their associated coefficients, $\beta_1^{q}, \beta_2^{q}, \beta_3^{q}, \beta_4^{q}$ (see table below). The quantile regressions are estimated at different points of the distribution of y_{t+h}^{q}, and each coefficient estimate, β_i^{q}, represents the macro-financial linkages between the variable $X_{i,t}$ and future capital flows at different points of the (forecasted) future capital flows distribution.

Finally, the coefficient estimates for the range of percentiles (from 10th to the 90th) are then used to construct the conditional forecast distribution of non-resident portfolio capital flows up to six-months ahead. With the distribution, the risks to capital flows can be identified by examining the lower tail of the distribution, and quantifying the volume of capital flows that would reach (or exceed) a certain probability—typically 5 percent. This amount is the estimated CfaR at the 5 percent level.

Description of Variables

Indicators	Unit	Sources
Dependent Variable		
• Non-resident (net) portfolio capital flows in ASEAN-4 and Korea (aggregate, sum)	% of GDP	Institute of International Finance
Independent Variables		
Domestic Macroeconomic Fundamentals		
• Real GDP of ASEAN-4 and Korea (aggregate, weighted by purchasing power parity)	% yoy	Haver Analytics
• Financial openness in ASEAN-4 and Korea (aggregate, simple average)	Level (Index)	Chinn and Ito (2006)
Trading Partners' Macroeconomic Fundamentals		
• US' real GDP	% yoy	Haver Analytics
• China's real GDP	% yoy	Haver Analytics
Domestic Financial Conditions (LSI)		
• LSI for ASEAN-4 and Korea	Level (Index)	AMRO staff estimates
Global Financial Conditions		
• Brent spot price	% yoy	Bloomberg
• US dollar index (DXY)	% yoy	Bloomberg
• US 10-year sovereign term premia	% pts (annual change)	Haver Analytics
• US 10-year real rates	% pts (annual change)	Haver Analytics
• Chicago Board Options Exchange's S&P500 index options (VIX)	Level (Index)	Bloomberg
Other Factors (External Vulnerabilities)		
• Short term external debt to reserves ratio in ASEAN-4 and Korea (aggregate, simple average)	% pts (annual change)	Haver Analytics
• Foreign holdings of local currency-denominated sovereign debt in ASEAN-4 and Korea (as share of total outstanding), (aggregate, simple average)	% pts (annual change)	ADB Bonds Online

Source: AMRO staff compilations

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