HONG KONG MONETARY AUTHORITY

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A FRAMEWORK TO MONITOR VULNERABILITY AND RESILIENCE OF THE EMEAP ECONOMIES

Key points

- *This study sets up a vulnerability indicator (VI) framework and a resilience indicator (RI) framework for the EMEAP economies that serves as the first-line monitoring tool for further in-depth assessment and policy deliberation.*

- *The VI consists of 24 economic and financial indicators grouping into five categories of vulnerabilities, namely macro, market, credit, US dollar liquidity and contagion, and the VI pentagon summarises the five vulnerabilities and identify the most serious vulnerability at any point of time.*

    - *Our VI framework shows that the macro, market and credit vulnerabilities in the EMEAP region reached their highest levels during the COVID-19 pandemic, exceeding their previous peaks during the 2008 GFC even though the more advanced economies in the EMEAP region also experienced severe vulnerabilities during the GFC due to their larger openness and higher financial connectedness. More recently, while other vulnerabilities have receded from their high levels seen in 2020, the credit vulnerability stayed elevated, suggesting that the pandemic impact on the EMEAP economies might shift from acute (i.e. macro and market risks) to chronic (i.e. credit risk).*

- *The RI framework consists of 14 indicators covering economic and institutional structures, and are grouped into four categories of resilience, namely macro, market, credit and banking, and US dollar liquidity. The RI heat-map summarises the resilience.*

    - *Our RI shows that AEs in the EMEAP region are in general more resilient than the region's EMEs. In particular, more efficient and effective government and businesses, as well as high household net worth have enabled AEs in the region fare better during the COVID-19 outbreak in 2020. Meanwhile, the swap-line between some EMEAP economies and the US Fed, as well as the continuous enhancement of the CMIM, have avoided a severe US*

dollar shortage during the pandemic, while banks' high capital adequacy and the high awareness of regulators in implementing macro-prudential measures have safeguarded the stability of the banking and financial system.

Prepared by: Tam Chi Sang
Economic Research Division, Research Department
Hong Kong Monetary Authority

The views and analysis expressed in this paper are those of the authors, and do not necessarily represent the views of the Hong Kong Monetary Authority.

I. INTRODUCTION

Financial crises in the past couple of decades typically happened in economies with severe vulnerabilities. Given that a number of economic and financial indicators (e.g. real exchange rate, domestic credit, credit to the public sector, inflation) were found to provide early warning signals to crises (Kaminsky et al (1998), Kaminsky (1999)), it would be useful to have a vulnerability framework that monitors these vulnerability indicators in an easy-to-read manner, which can allow policymakers to assess potential threats and act pre-emptively to avoid crises.

To facilitate macro-financial surveillance of the EMEAP region, this study sets up a vulnerability indicator (VI) framework to monitor the vulnerabilities in the EMEAP region. Similar to the Financial System Vulnerabilities Monitor produced by the US Office of Financial Research (McLaughlin et al, 2018) and Dalhaus and Lam (2018), this study uses a non-parametric distribution approach to measure the vulnerability level as reflected by 24 common indicators, which are organised into five groups of vulnerabilities: (1) macro, (2) market, (3) credit, (4) US dollar liquidity, and (5) contagion. An economy is more threatened by a particular type of vulnerability if that particular group of indicators moves towards extreme values that are unusually seen in the past. The VI has been presented as a pentagon chart in the Macro Monitoring Report (MMR) since the Jun 2020 MFSC meeting, facilitating the identification and tracking of key vulnerabilities across time.

Apart from vulnerability, this study also sets up a resilience indicator (RI) framework, which gauges an economy's capability to *cope with economic disruptions brought by any materialised shocks*. The concept of resilience has also been studied in the economic literature, although not as extensive as the concept of vulnerability. For example, Brown and Greenbaum (2017) found that, in the US, counties with less industrial diversification are generally less resilient to unemployment shocks than those counties with more industrial diversification. In their study on Financial System Resilience Index, the UK based think tank New Economics Foundation (NEF) (NEF, 2015) identified several determinants of the financial system resilience, including the diversity of financial system, interconnectedness of financial institutions, and the bank asset to capital ratios. As an effort to complete the picture, this study consolidates a set of resilience indicators into a heat-map for surveillance.

The rest of this paper is organised as follows. Section 2 discusses the principles of selecting indicators for constructing the VI and the distribution approach used to construct the VI. Section 3 presents the estimated VI and illustrates how the approach is useful to monitor the evolution of vulnerabilities. Section 4 discusses the RI concept, selection of the resilience indicators and the heat-map approach. Section 5 presents a consolidated chart that summarises the RI and VI. Section 6 concludes the study.

II. VULNERABILITY INDICATORS

2.1 Selecting vulnerability indicators

The indicator selection begins with a review of the literature, including empirical studies performed by both academia and official sectors. The selection should reflect the five types of vulnerability: (1) macro, (2) market, (3) credit, (4) US dollar liquidity, and (5) contagion, subject to the following practical constraints:

- First, the selected indicators should be available for most EMEAP economies in order to produce an aggregated regional VI picture.

- Second, to allow the VI track vulnerabilities over time, the selected indicators should have a sufficiently long time series data (which begins in 2006)[1].

- Third, to provide a timely assessment, we tend to select indicators with short publication-lag. For important indicators with long publication lag (e.g. current account balance), we use the consensus forecast for these indicators as appropriate.

[1] There are three reasons for choosing 2006 as the sample's starting point. First, as an important crisis episode, we want the estimation to capture the indicators' pattern right before and during the GFC. Second, as most EMEAP economies have experienced fast market and economic development over the past few decades, it would be misleading (in the vulnerability and resilience sense) to compare recent data with that in 1980s or 1990s. Third, many market indicators used in the VI and EI are available only after mid-2000s.

- Fourth, to include as much useful information as possible, we do not require the selected indicators to have the same frequency, and data frequency could be quarterly, monthly, weekly and daily.[2]

Table 1 lists the 24 selected indicators grouping into the five types of vulnerabilities. Column 3 indicates that the indicator is considered to be riskier if it lies at the lower end of the distribution (i.e. left-tailed risk), higher end of the distribution (i.e. right-tailed risk) or at both extremes. The corresponding scoring equations and the normalisation of risk scoring are discussed in Section 3.

Table 1. Indicators in the VI

Risk type	**Indicator**	**Frequency**	**High risk at higher end/ lower end/ both extremes?**	**Source**
Macro	Real GDP growth (%yoy)	Q	Lower end	Oxford Economics
Macro	CPI inflation (%yoy)	M/Q	Both extremes	CEIC
Macro	Fiscal balance (%GDP)	Q	Lower end	Oxford Economics
Macro	Current account (%GDP)	Q	Lower end	Oxford Economics
Macro	Cross-border liabilities (%GDP)	Q	Higher end	BIS
Macro	External debt (%GDP)	Q	Higher end	Oxford Economics
Market	Exchange rate (LCY per USD)	D	Both extremes	Bloomberg
Market	Equity PE (ratio)	D	Higher end	Bloomberg
Market	Sovereign bond yield spread (vis a vis UST) (bps)	D	Higher end	Bloomberg
Market	High yield bond spread (government-spread) (bps)	D	Higher end	JPM
Market	Residential housing price index (Index)	W/M/Q	Higher end	CEIC
Credit	Household credit (%GDP)	Q	Higher end	BIS/HKMA
Credit	NFC credit (%GDP)	Q	Higher end	BIS/HKMA

[2] Half-yearly and Annual data are not included as they might not be timely enough to reflect the latest vulnerability.

Credit	Government credit (%GDP)	Q	Higher end	BIS
Credit	Asia-Pacific average OAS (Bloomberg Barclays index series) (bps)	D	Higher end	Bloomberg
Credit	Sovereign CDS (bps)	D	Higher end	Bloomberg
Credit	Non-performing loans to total loans (ratio)	Q	Higher end	IMF
USD liquidity	Cross currency basis swap (bps)	D	Lower end	Bloomberg
USD liquidity	Corp bond yield spread (USD bond)	D	Higher end	JPM
USD liquidity	Portfolio funds outflows (equity) (% accumulated funds)	W	Lower end	EPFR
USD liquidity	Portfolio funds outflows (bond) (%accumulated funds)	W	Lower end	EPFR
Contagion	VIX (index)	D	Higher end	Bloomberg
Contagion	Dummy (High contagion risk if SPX loses more than 2% in the previous trading day)	D	Higher end	Bloomberg
Contagion	Dummy (High contagion risk if other Asian benchmark equity indices loses more than 2.5% in the previous trading day)	D	Higher end	Bloomberg

Source: HKMA staff.

2.2 Scoring the indicators – the distribution approach

In principle, we estimate the "vulnerability score" (u) of each indicator by ranking each observation in its own history since the beginning of the data sample. That means, the estimated vulnerability score reflects how high (or how low) the level of an indicator at a particular point of time compared to its time series. The score is then standardised to the [0.5, 1] interval (V), with the lower score (i.e. closer to 0.5) indicating that the vulnerability corresponding to that indicator is low; while a higher score (i.e. closer to 1) indicating that the vulnerability level is higher.

In practice, for each indicator of each economy, we estimate the empirical

cumulative density function (CDF) of each observation in its own time series. For example, at time t, we estimate the CDF ($u_{i,x,t}$) of an indicator *x* of an economy *i*. If *x* is left-tailed (i.e. implies larger vulnerability if *x* is smaller), then a very close to zero $u_{i,x,t}$ implies that country i is vulnerable in terms of *x* compared to other time periods in the sample. Meanwhile, there are some right-tailed indicators (i.e. implies larger vulnerability if the indicator is larger) and some "vulnerable at both extremes" indicators in the VI indicator list (see Table 1). To unify the direction of the risk score, we standardise the CDF by the method suggested by Dahlhaus and Lam (2018):

$$V_{i,x,t} = \begin{cases} 0.5 + max(u_{i,x,t} - 0.5, 0) \text{ if x is right-tailed} \\ 0.5 + max(0.5 - u_{i,x,t}, 0) \text{ if x is left-tailed} \\ 0.5 + max(u_{i,x,t} - 0.5, 0.5 - u_{i,x,t}) \text{ if both extremes of x imply vulnerabilities} \end{cases} \quad (1)$$

The risk scores of the five types of vulnerabilities are then calculated by taking the simple average of indicators' risk scores under each type of vulnerability. Indicators with different frequencies may involve in the construction of the aggregated vulnerability. In that case, the risk scores of the latest observation of lower frequencies indicators (i.e. quarterly, monthly and weekly) will be aggregated with that of the daily data. This approach enables us to update the VI on a daily basis.

To construct the VI for regions and groups of economies, we take the simple average of economies' risk scores in the economy group.

This non-parametric distribution approach together with the simple average aggregation possess an advantage over the parametric approach: without regression or other parameter estimation, it is very easy to add or drop indicators to or from this framework. Such flexibility is important for monitoring the EMEAP region amid the fast economic and financial market development in the region as well as the ongoing structural changes in the global economy (e.g. digitalisation, growing importance of the ESG).

For cross-economy comparison, a potential issue of this approach is that we do not rank or compare the indicator level *across economies* directly in the CDF estimation. Given that the CDF of a particular indicator in an economy is estimated from the indicator's own time series of that economy, at any period *t*, a higher CDF value (i.e. higher *u*) of an indicator in Economy A than that in

Economy B does not imply that the indicator level in Economy A is higher than that in Economy B, but just means that A's indicator value's ranking at time *t* in A's own time series is higher than B's indicator value's ranking at time *t* in B's own time series.

Nonetheless, we believe that our approach is more meaningful than comparing the indicator level directly across economies, as the indicator's distribution could be very different from one economy to another depending on the economies' fundamentals, development status, policy settings, etc. For example, an economy with a sizable financial centre could have a persistently much higher corporate credit level than other economies. As such, comparing the corporate credit level of a financial centre with other economies could not really tell which economy is more vulnerable. A more meaningful comparison is to check whether the level of corporate credit in each economy is too high compared to its own history, followed by a cross-economy comparison of this "abnormality" to tell which economy is more vulnerable.

III. VULNERABILITY INDICATORS FOR EMEAP ECONOMIES

3.1 The evolution of VI since 2000s

The standardised vulnerability score of the 24 indicators for 11 EMEAP economies are estimated according to Equation (1). They are aggregated to the risk scores of the five major types of vulnerabilities. From the time series of the risk scores of the EMEAP region, there are three important observations:

1. *The macro, market and credit vulnerabilities reached their highest level during the COVID-19 pandemic, exceeding their previous peaks during the 2008 Global Financial Crisis (GFC). Meanwhile, the US dollar liquidity vulnerability seen during the pandemic outbreak was smaller than that during the 2008 GFC.*

   During the GFC, the macro vulnerability score of the EMEAP region increased from less than 0.66 in Q2 2008 to about 0.7 in Q4 2008 and then further edged up to 0.73 in 2019 before receding gradually in 2010. During the COVID-19 outbreak, the macro vulnerability score jumped from less than 0.7 in end 2019 to 0.83 in Q2 2020 (Chart 1). This means that the macro vulnerability intensified more rapidly amid the COVID-19

pandemic outbreak. The market vulnerability score and the credit vulnerability score also showed similar pattern (Chart 2, Chart 3), while the contagion vulnerability reached a similar high level during the pandemic compared with that during the GFC (Chart 4). The high risk scores seen during the COVID-19 outbreak indicate that the pandemic posed an unprecedented large negative shock to the EMEAP economies than that of the GFC.

Chart 1. EMEAP: Macro risk

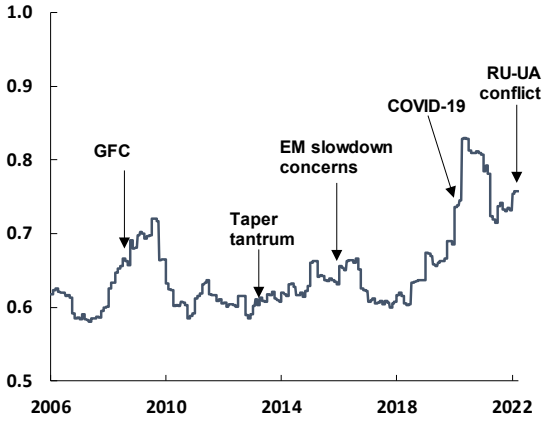


Chart 2. EMEAP: Market risk

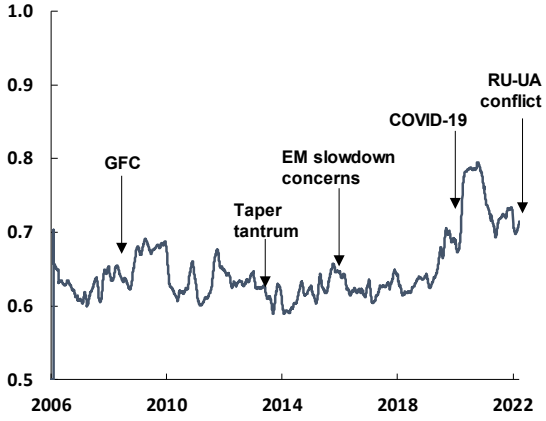


Chart 3. EMEAP: Credit risk

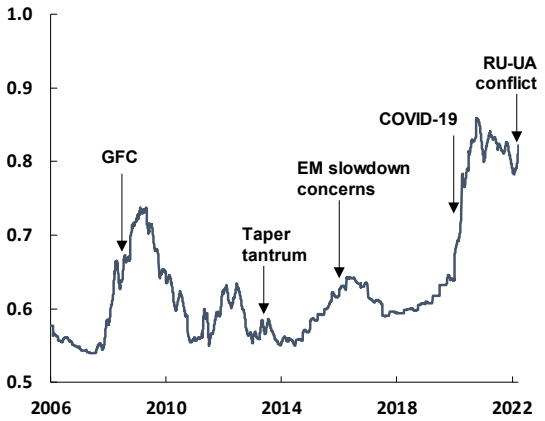
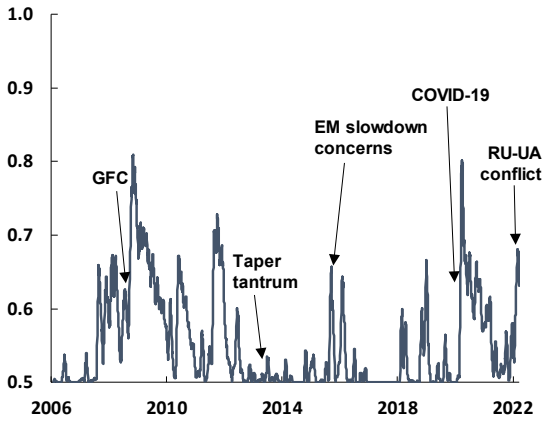


Chart 4. EMEAP: Contagion risk

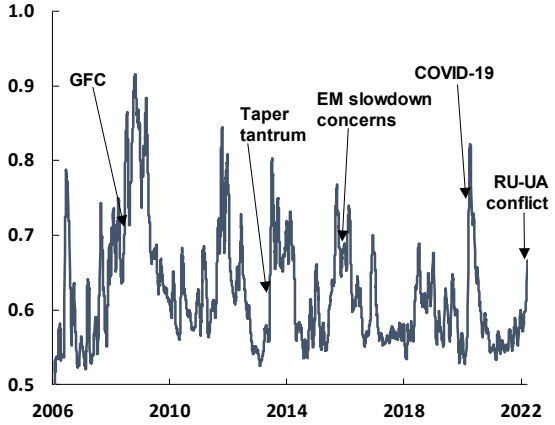


Source: HKMA staff estimates.

Meanwhile, although the US dollar liquidity risk score also surged during the pandemic outbreak in early 2020, it was significantly lower than the peak recorded during the GFC (Chart 5). The lower US dollar liquidity vulnerability during the pandemic outbreak may be attributed to several factors. First, unlike the GFC which was triggered by broader financial sector distresses, the pandemic shock is not financial sector-centric and thus caused less destabilisation to the banking and financial sectors in the

first place. Second, benefited from the lesson learned from the GFC, global central banks, including those in the EMEAP region, reacted much faster to the pandemic shock by providing strong liquidity supports to both financial and non-financial sectors. Third, to enhance and secure the US dollar liquidity during market stress, central banks of some EMEAP economies (Australia, Japan, New Zealand, Singapore and South Korea) have established or strengthened the US dollar swap line with the US Fed. Meanwhile, many other EMEAP economies have enhanced the regional financial safety net (e.g. CMIM) to heighten the regional coordination in securing liquidity provision for emergency (also see discussion in the later section on resilience).[3] All these factors might have reduced the region's US dollar liquidity vulnerability during the COVID-19 outbreak.

Chart 5. EMEAP: US dollar liquidity risk



Source: HKMA staff estimates.

2. *In comparison to the EMs[4], the more advanced economies in the EMEAP region[5] faced larger vulnerabilities during the GFC (Charts 6-8).*

This could be attributed to the larger openness and higher connectedness of advanced EMEAP economies to the global financial system, which made their domestic economies and financial sectors more susceptible to

[3] ASEAN+3 members reached a consensus to increase the IMF de-linked portion to 40% from 30%. The amendment allows members to get access to greater and faster financial support without an IMF program. ASEAN+3 members also decided to institutionalise the use of local currencies, in addition to the dollar, for CMIM financing on a voluntary and demand-driven basis. The group also performed multiple test runs on the CMIM mechanism to understand and minimise the potential operational risks of the mechanism in case of emergency.

[4] According to the IMF WEO, Mainland China, Indonesia, Malaysia, the Philippines and Thailand are developing economies in the EMEAP region.

[5] According to the IMF WEO, Australia, Hong Kong SAR, Japan, New Zealand, Singapore and South Korea are advanced economies in the EMEAP region.

global financial shocks. Nevertheless, the risk scores of both advanced and emerging EMEAP economies reached similar high level during the pandemic outbreak in early 2020, reflecting the widespread and broad impacts of the pandemic.

Chart 6. AEs and EMEs in the EMEAP region: Macro risk

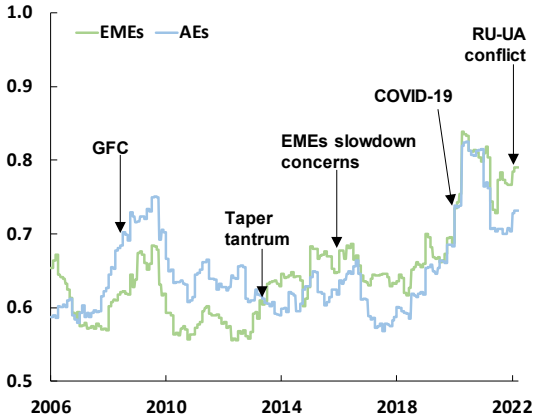


Chart 7. AEs and EMEs in the EMEAP region: Market risk

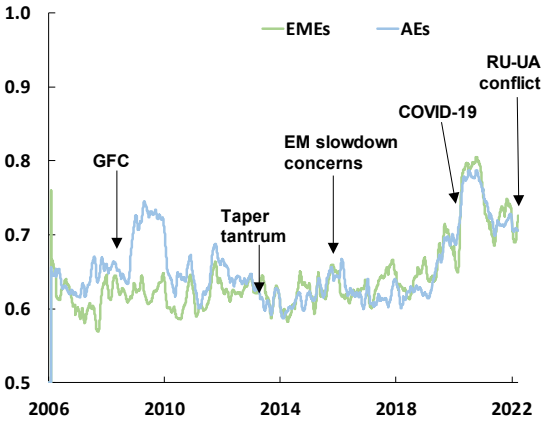
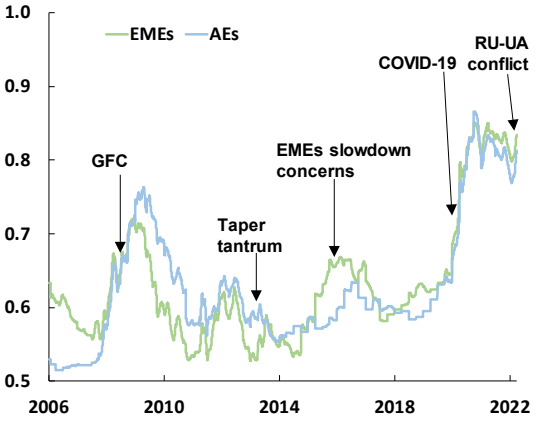


Chart 8. AEs and EMEs in the EMEAP region: Credit risk



Source: HKMA staff estimates.

3. *While other vulnerabilities have receded from their high levels seen in 2020, the credit vulnerability score stayed elevated.*

In fact, although the macro vulnerability score of the EMEAP region remained high in late March 2021, it has declined significantly from the peak seen in mid-2020. Meanwhile, the score of market vulnerability, contagion vulnerability and US dollar liquidity vulnerability have also decreased significantly compared to their peaks in 2020, whereas the credit vulnerability score have seen little change, suggesting that **the**

pandemic impact on the EMEAP economies might shift from acute (i.e. macro and market risks) to chronic (i.e. credit risk).

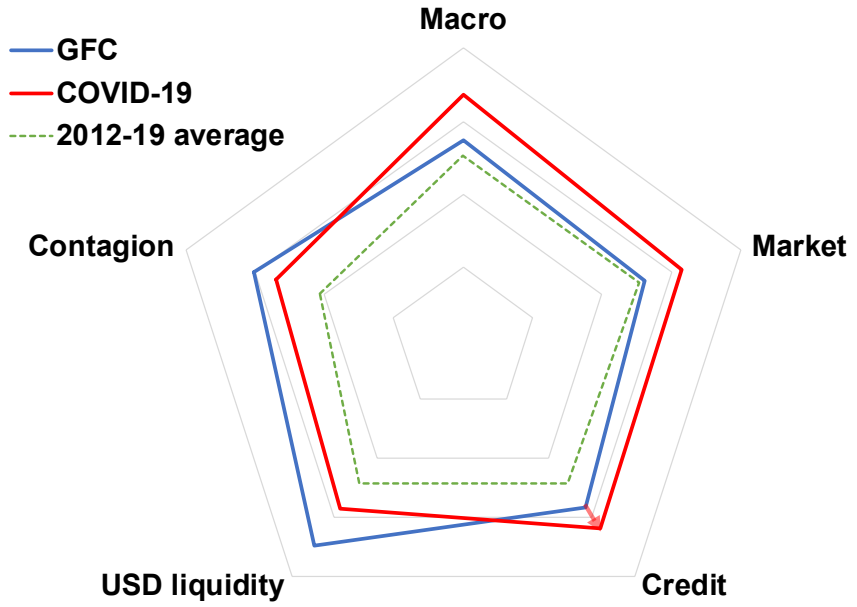
3.2 The VI pentagon – a snapshot of the vulnerability level

Apart from comparing any vulnerability across time, our framework can also identify the most serious vulnerability at any point of time. In this regard, we produce the VI pentagon, i.e. a radar chart that displays the five types of vulnerabilities at any point of time, with each vertex indicating the risk score of a particular type of vulnerability. A key advantage of radar chart is that reader can easily identify any outlier from the shape of the pentagon. Also, the shift in the shape of the pentagon over time can tell us the transition of key vulnerability from one type to another.

Chart 9 shows the VI pentagons during the GFC (2008 Q4), the outbreak of the COVID-19 pandemic (2020 Q2) and the 2012-2019 average (as a non-crisis long term average reference). It shows that the macro, market and credit vulnerabilities in the EMEAP region were larger during the pandemic outbreak than during the GFC, while the US dollar liquidity and the contagion vulnerabilities were higher during the GFC.

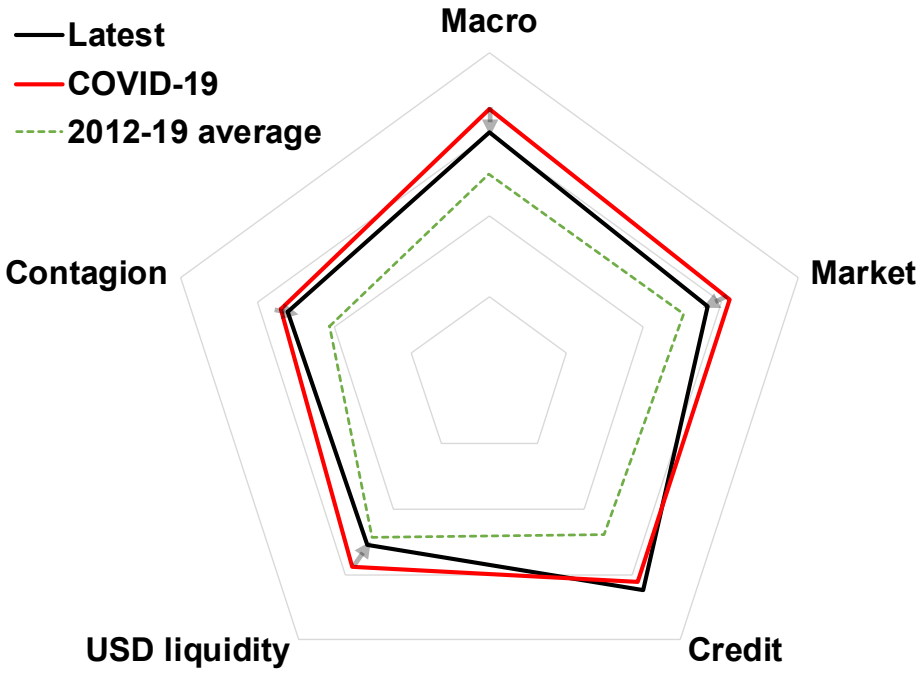
Chart 10 shows the VI pentagons during the pandemic outbreak (2020 Q2), the latest situation (March 2022) and the 2012-2019 average. It shows that most vulnerabilities except credit vulnerability have eased from the pandemic highs, despite still higher than the non-crisis average level.

Chart 9. The VI pentagon: GFC vs. COVID-19 pandemic outbreak



Source: HKMA staff estimates.

Chart 10. The VI pentagon: COVID-19 pandemic outbreak vs. latest



Note: "Latest" refers to March 2022.
Source: HKMA staff estimates.

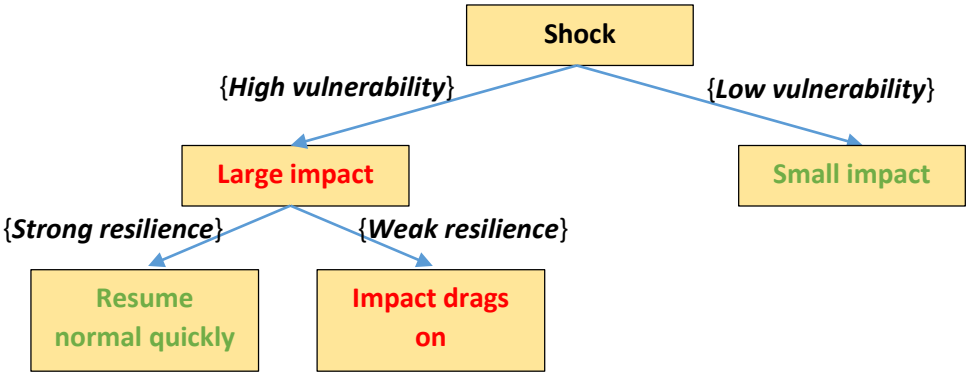
The VI pentagon serves as the first-line monitoring tool and forms the basis for a more in-depth risk assessment. For example, with the VI pentagon showing still-elevated credit vulnerability, the June 2021 MMR highlighted the risk from the "pre-matured global financial conditions tightening", as such risk could collide with the credit vulnerability and cause severe negative economic and financial consequences. The MMR then proposed policy suggestions accordingly.

IV. RESILIENCE INDICATORS

4.1 The concept

For a holistic assessment of risks, we need to consider not only vulnerability but also resilience, which concerns the ability of an economy to maintain normal functions in response to any shock. Chart 11 conceptually illustrates how an unexpected shock could affect an economy with different levels of vulnerability and resilience. As shown, an economy with high vulnerability may resume quickly from the disruptions brought by the shock as long as it also has high resilience, i.e. small "net vulnerability" despite high "gross vulnerability".

Chart 11. Shock, vulnerability and resilience



Source: HKMA staff.

One possible way to assess resilience is to think about attributes and characteristics that would determine the capabilities of an economy to cope with any particular vulnerability when that vulnerability is crystallised by a shock. For example, lockdowns and surges in hospitalisation during the COVID outbreak in 2020 have highlighted the macro vulnerability of all EMEAP economies and put their resilience to test. The subsequent development demonstrated that an economy with an efficient government (which is capable

to roll out appropriate public hygiene measures) and a flexible business sector (which is capable to modify their business operations to adapt the containment measures) managed to emerge from the pandemic disruption earlier than others. Therefore, the indicators of "government effectiveness" and "business efficiency" could be included in the set of resilience indicators.

Meanwhile, the surge in indebtedness in both private and public sectors since the pandemic outbreak has heightened the credit vulnerability of all EMEAP economies, but with the strong capital adequacy of the region's banking sector, as well as sufficient macroprudential measures rolled out by regulators, the region is likely to be capable of handling any funding shock down the road. As such, the banking sector capital adequacy ratio and the number of macroprudential measures in place could be included in the set of resilience indicators.

4.2 Selecting resilience indicators

As very few references are available from the literature, we select the resilience indicators to align with the definition as much as possible. Table 2 lists the set of 14 resilience indicators. They are organised into four groups, namely (1) macro, (2) market, (3) credit and banking and (4) US dollar liquidity.

Table 2. Resilience indicators

Resilience type	**Indicator**	**Frequency**	**Strong resilience at higher end/ lower end/ both extremes?**	**Source**
Macro	Trading partners diversity index (0 to 1 index)	Y	Lower end (larger diversity)	World Bank (WITS)
Macro	Export products diversity index (0 to 1 index)	Y	Lower end (larger diversity)	UN (UNCTAD)
Macro	Government effectiveness (-2.5 to 2.5 index)	Y	Higher end	World Bank (WGI)
Macro	Business efficiency (percentile)	Y	Higher end	IMD
Macro	Digital competitiveness (percentile)	Y	Higher end	IMD
Macro	Household net worth to liabilities ratio (ratio)	Q/Y	Higher end	CEIC/HKMA

Market	Yearly average stock market turnover ratio	Y	Higher end	WDI
Market	Bond turnover ratio	Y	Higher end	ADB (ABO)
Market	FX turnover (share of world total)	Y	Higher end	BIS (Triennial survey)
Credit and Banking	Regulatory capital to risk-weighted assets ratio	Q	Higher end	IMF/CEIC
Credit and Banking	Number of macroprudential policy measures in place	Y	Higher end	IMF (Macroprudential policy survey)
USD liquidity	Swap line with the US (have/have not)	N.A.	(Have)	Official sources
USD liquidity	Right to request USD liquidity support from the CMIM (have/have not)	N.A.	(Have)	ASEAN+3
USD liquidity	FX reserves (no. of month of imports)	Q	Higher end	Oxford economics

Source: HKMA staff.

Compared to the fast-moving and more market-based indicators of the VI, the definition of resilience implies that the possible resilience indicators are likely to be more structural and thus usually slow-moving.

4.3 The resilience heat-map

As the resilience indicators have lower frequencies and shorter samples, the VI's distribution approach is less suitable for summarising the region's resilience. Instead, a heat-map appeared to be a more feasible alternative. To map the resilience, each indicator is colour-coded based on its level relative to its possible range (e.g. diversity index), ranking among all economies in the data source (e.g. digital competitiveness) or some conventional thresholds in the literature (e.g. Basel III required CAR: 10.5%; IMF-recommended foreign reserves-to-import coverage: at least six months). Three different colours – green, yellow and red – are used to represent three levels of resilience, namely (1) strong resilience; (2) normal resilience and (3) weak resilience, respectively. Table 3 lists the colour-coding schedule of the resilience indicators.

Table 3. Resilience indicators – colour-scoring schedule

Resilience type	Indicator	Strong resilience	Normal resilience	Weak resilience
Macro	Trading partners diversity index (0 to 1 index)[1]	x≤0.33	0.33<x≤0.66	0.66<x
Macro	Export products diversity index (0 to 1 index) [1]	x≤0.33	0.33<x≤0.66	0.66<x
Macro	Government effectiveness (-2.5 to 2.5 index) [1]	x>0.83	0.83≥x>-0.83	-0.83≥x
Macro	Business efficiency (percentile) [1]	x>66	66≥x>33	33≥x
Macro	Digital competitiveness (percentile) [1]	x>66	66≥x>33	33≥x
Macro	Household net worth to liabilities ratio (ratio) [5]	x>6	6≥x>3	3≥x
Market	Yearly average stock market turnover ratio (% of domestic share)[3]	x>31	31≥x>6	6≥x
Market	Government bond turnover ratio (% of outstanding government bond) [2]	x>260	260≥x>129	129≥x
Market	FX turnover (% of world total) [3]	x>2	2≥x>0.55	0.55≥x
Credit and Banking	Regulatory capital to risk-weighted assets ratio[4]	x>15.75	15.75≥x>10.5	10.5≥x
Credit and Banking	Number of macroprudential policy measures in place[2]	x>19	19≥x>11	11≥x
USD liquidity	Swap line with the US (have/have not) [6]	Have	--	Have not
USD liquidity	Right to request USD liquidity support from the CMIM (have/have not) [6]	Have	--	Have not
USD liquidity	FX reserves (no. of month of imports) [4]	x>9	9≥x>6	6≥x

Notes: 1. Simply divide the index range / percentile into three equal sections (i.e. 33% each) and assign the corresponding resilience colour score. 2. Estimate the 33rd and 66th percentiles of the indicators across EMEAP economies at the latest available time period. Indicator levels above the 66th percentile, between 33rd and 66th percentiles and below 66th percentile are assigned as strong, normal and weak resilience respectively. 3. Estimate the 33rd and 66th percentiles of the indicators across all economies that are available from the data source at the latest available time period. Indicator levels above the 66th percentile, between 33rd and 66th

percentiles and below 66th percentile are assigned as strong, normal and weak resilience respectively. 4. The commonly regarded safe-threshold regarded as the minimum value of "normal resilience". Indicator that exceeds 150% of this threshold is considered to be of "strong resilience". 5. The colour-code is judgemental, as only six AEs in the region have the data of household net worth and liabilities. 6. Binary indicator will only be scored as "strong resilience" or "weak resilience".
Source: HKMA staff.

4.4 Resilience of EMEAP economies

Chart 12 is the resilience heat-map of EMEAP economies grouped into AEs and EMEs. The economy-group aggregation is done by a simple averaging of the indicators across the economies. As shown, the region is resilient in general, with most indicators having "strong resilience". AEs in the region are a bit more resilient than regional EMEs. On the macro front, AEs' governments and businesses are likely to be more efficient and effective, as well as having higher digital competitiveness. These observations apparently reflect the difference in the status of economic and social developments. On the financial market front, the bond market and FX market turnover ratios in the region's AEs are also larger than that in the region's EMEs, implying that AEs markets are more liquid and thus more capable to cope with disruptions during market stress. Meanwhile, while many AEs in the EMEAP region are resilient against US dollar liquidity shock as they could tap the US Fed for US dollar liquidity, none of the region's EMEs possess the swap line with the US Fed.

The resilience heat-map also explains how the region fared during the pandemic disruptions. While the COVID-19 outbreak in early 2020 hit the region with lockdowns and large pressures on the public hygiene system, many EMEAP economies, especially those AEs with more efficient and effective government and business sector as well as more digitalised environment, have coped with the difficulties and restored normal function soon after the initial shock, while their financial markets also functioned orderly despite bouts of volatility. Meanwhile, the ample foreign exchange reserves, together with the swap-lines between the US Fed and the continuous efforts to enhance the CMIM by EMEAP economies, helped avoid a severe US dollar funding stress. The region's banking system also remained resilient as it has adequate capital relative to the its risk-weighted assets, and regulators have rolled out multiple macro-prudential policy measures to rein in risks.

Chart 12. EMEAP economies: Resilience heat-map

Type	Indicator	AEs	EMEs
Macro	Trading partners diversity		
Macro	Export products diversity		
Macro	Government effectiveness		
Macro	Business efficiency		
Macro	Digital competitiveness		
Macro	Household net worth to liabilities		(n.a.)
Market	Stock market turnover ratio		
Market	Government bond turnover ratio		
Market	FX turnover		
Credit and Banking	Regulatory capital to risk-weighted assets ratio		
Credit and Banking	Number of macroprudential policy measures in place		
USD liquidity	Swap line with the US FED		
USD liquidity	CMIM participation		
USD liquidity	FX reserves		

Note: Please refers to Table 3 for the legend. Latest observations range from 2019 to 2021.

Source: HKMA staff estimates

V. VULNERABILITY AND RESILIENCE INDICATORS IN ONE CHART

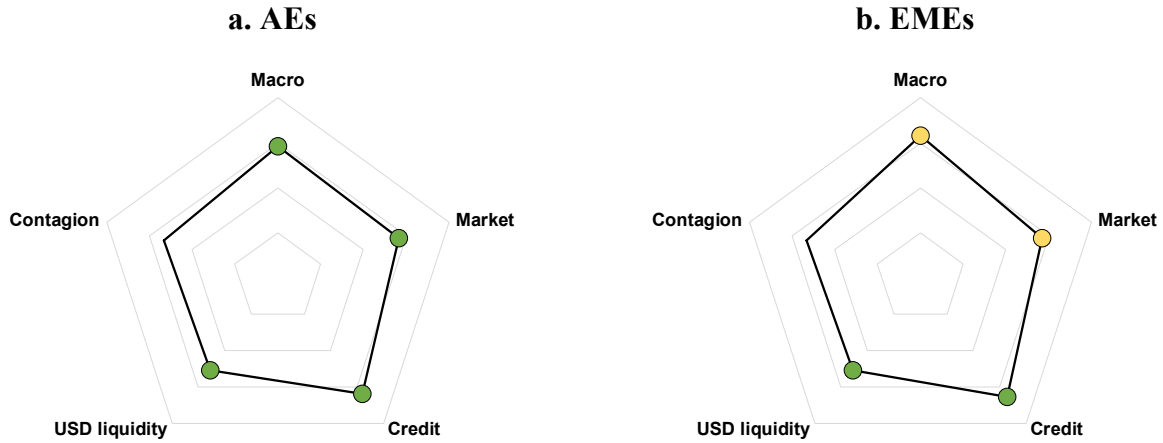
This study also offers a qualitative assessment of the "net vulnerability". Based on the vulnerability indicators and the corresponding resilience indicators, we can summarise these indicators by producing a consolidated chart, even though the vulnerability and resilience indicators are scaled and measured in a different way.

Charts 13a and 13b provides a consolidated chart summarising both the vulnerability and the resilience of AEs and EMEs in the EMEAP region, with circular markers being added to the vertices of the VI pentagon to highlight the resilience in macro, market, credit and USD liquidity.[6] The markers are coloured according to the major resilience level of that group of indicators in the resilience heat-map. For example, according to Chart 12 (i.e. the heat-map), five out of six macro resilience indicators in AEs are green, therefore the resilience marker on the macro vertex of the AEs' pentagon is coloured in green. Meanwhile, three out of five macro resilience indicators in EMEs are yellow, therefore the

[6] There is no marker on the contagion vertex as we have not identified any "contagion resilience indicator" in the resilience indicators framework.

resilience marker on the macro vertex of the EMEs' pentagon is coloured in yellow. As shown, while AEs and EMEs in the EMEAP region are facing similar level of vulnerabilities, the more resilient AEs, in terms of macro and market indicators, imply a lower net vulnerability in AEs.

Chart 13. Summary of RI and VI



Note: The latest vulnerability indicators are as of March 2022; while that of resilience indicators are ranging from 2019 to 2021.
Source: HKMA staff estimates

VI. Conclusion

This study sets up a vulnerability indicator (VI) framework and a resilience indicator (RI) framework for the EMEAP economies that serves as the first-line monitoring tool for further in-depth assessment and policy deliberation.

The VI consists of 24 economic and financial indicators grouping into five categories of vulnerabilities, namely macro, market, credit, US dollar liquidity and contagion, and the VI pentagon summarises the five vulnerabilities and identify the most serious vulnerability at any point of time.

Our VI framework shows that the macro, market and credit vulnerabilities in the EMEAP region reached their highest levels during the COVID-19 pandemic, exceeding their previous peaks during the 2008 GFC even though the more advanced economies in the EMEAP region also experienced severe vulnerabilities during the GFC due to their larger openness and higher financial connectedness. More recently, while other vulnerabilities have receded from their high levels seen in 2020, the credit vulnerability stayed elevated, suggesting

that the pandemic impact on the EMEAP economies might shift from acute (i.e. macro and market risks) to chronic (i.e. credit risk).

The RI framework consists of 14 indicators covering economic and institutional structures, and are grouped into four categories of resilience, namely macro, market, credit and banking, and US dollar liquidity. The RI heat-map summarises the resilience.

Our RI shows that AEs in the EMEAP region are in general more resilient than the region's EMEs. Indeed, more efficient and effective government and businesses, as well as high household net worth have enabled AEs to fare well during the COVID-19 outbreak in 2020. Meanwhile, the swap-line between some EMEAP economies and the US Fed, as well as the continuous enhancement of the CMIM, have avoided a severe US dollar shortage, while banks' high capital adequacy and the high awareness of regulators in implementing macroprudential measures have safeguarded the stability of the banking and financial system.

The key advantage of this approach is that it can provide a qualitative assessment of the "net vulnerability". We produced a consolidated chart to show how the VI and RI could jointly indicate the net vulnerability of the EMEAP economies. This could serve as a quick monitoring tool for economic and financial stability surveillance.

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