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Special Column on China’s Energy Policy

China’s Policy Transition from Energy to Emissions Control: An Evaluation of Provincial Trends and Potentials

By XINYUE LI, ANDY MILLER, JENNA BEHRENDT, JIAYI ZHANG, YANG LIU, RYNA CUI [*]

Introduction

Every five years, the central government develops a national Five-Year Plan (FYP) with detailed economic development guidelines, which subnational governments use to develop their own provincial FYPs. These FYPs are a key tool for climate governance in China, and have previously focused on energy intensity reduction (see Figure 1). In the 15th FYP (2026-2030), emission intensity is prioritized before emissions peaking is achieved. Once carbon peaking is achieved, the system will shift to prioritize absolute emissions control, with intensity control becoming secondary. This policy shift indicates China's transition from a fossil-centered energy system and the decoupling of energy consumption from emissions. Such evolution in climate governance will help set the stage for China's carbon neutrality goal by explicitly targeting emissions reduction.

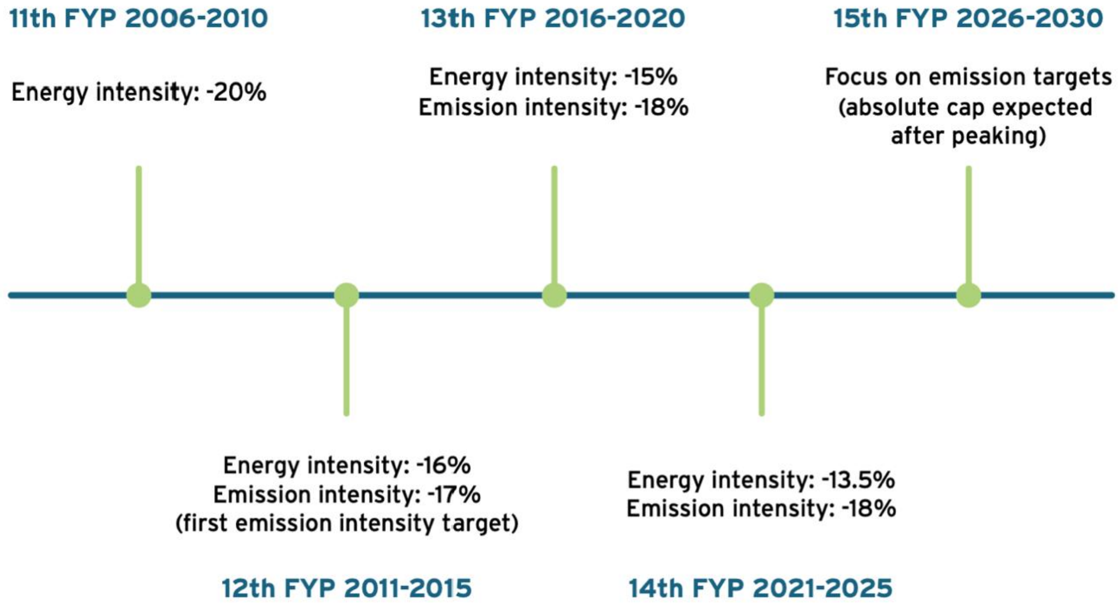

Figure 1. China’s Five-Year Plans: National energy and emission intensity reduction targets.

Provinces will play a critical role as the implementers of China's dual carbon control mechanism in the 15th FYP and in helping China achieve long-term national climate goals. In response to the national 15th FYP recommendations from the central government in October 2025, 30 provincial governments have put "dual carbon control" in their recommendations for provincial 15th FYPs as of February 2026. However, provinces vary significantly, with different levels of economic growth, industrial structures, and energy supply and consumption patterns. Literature has examined energy intensity or carbon intensity across provinces, analyzing the regional differences and influential factors along the intensity reduction. Differences in provincial decarbonization pathways reflect the varied stages of China's transition, representing not only the current but also potential future trajectories for the country as a whole. Examining progress under prior FYPs can identify some of these regional differences and inform strategies at both provincial and national level under future FYPs.

This study examines provincial trends in energy and emission intensity during the 13th FYP period (2016-2020), and emission intensity and absolute emission trends in the 14th FYP period (2021-2025) through 2023 to: 1) evaluate provincial progress in meeting energy and emission intensity targets, 2) identify underlying provincial differences in factors that contribute to energy and emission intensity reduction, and 3) examine factors that may influence performance under the new emissions control framework. By jointly assessing and comparing provincial trends in energy and emissions intensities, this

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analysis helps identify underlying drivers across different policy frameworks and strategies for supporting provinces, and China as a whole, to achieve emissions reductions during post-peaking.

Data and Methods

This analysis collected and processed emission and energy data from 2015 to 2022 from the Carbon Emission Accounts and Datasets (CEADs). The emission data in 2023 is projected based on the 2022-2023 emission growth from Multi-Resolution Emission Inventory Model for Climate and Air Pollution Research (MEIC). In this policy brief, energy intensity is calculated as the total primary energy consumption (average efficiency) per unit of GDP; the emission intensity is calculated as the energy CO2 emissions per unit of GDP. GDP data from 2015 to 2023 is collected and processed from the National Bureau of Statistics (NBS). Differences may arise between the results presented in this analysis and the official evaluation reported in the FYP work reports (see Table S1). Such discrepancies are primarily due to the use of different data sources and accounting methodologies for evaluating provincial energy and emission intensity.

Tracking Progress During the 13th FYP (2016-2020)

Energy Intensity

In general, China has reduced energy intensity under the 13th FYP, with different progress across provinces. At the national level, China's energy intensity was reduced by 13.2% from 2015 to 2020. At the subnational level, 22 of the 30 analyzed provinces met their provincial targets, among which Shanghai, Guizhou, and Sichuan had the highest energy intensity reduction at 33%. Beijing had the lowest energy intensity, while Shanxi had the highest (see Figure 2(A)). Most provincial targets were equal to or exceeded the national target, except for in the northwestern and southwestern provinces, which have a relatively lower energy efficiency level compared with the national average.

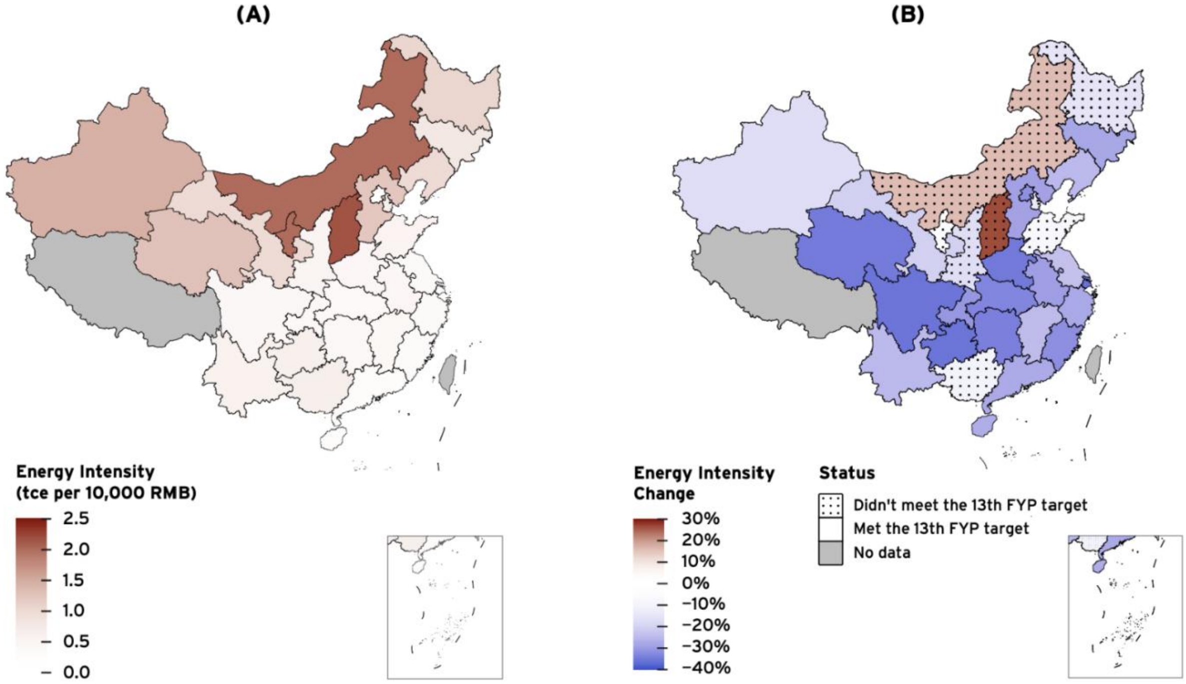


Figure 2. Energy intensity level by province in 2020 and change in provincial energy intensity from 2015 to 2020. Map (A) shows the absolute energy intensity (tce per 10,000 RMB) by province in 2020. Map (B) shows the energy intensity change by province from 2015 to 2020. Provinces with dots did not achieve their provincial 13th FYP energy intensity targets (or against the national target if provincial targets are not specified). Energy intensity is calculated based on methodology in Data and Methods and may differ from official claims. No data for Tibet, Taiwan, Hong Kong SAR, and Macau SAR.

Provinces that didn't meet their 13th FYP target in 2020 largely had increasing energy consumption and/or slow GDP growth. These provinces are mostly in the northern part of China and typically have energy-intensive industrial structures and high seasonal demand, and had rapid growth in primary energy consumption over the time period evaluated. Primary energy consumption increased in some of these provinces because of rising industrial demand, especially in energy-intensive sectors such as coal mining and seasonal heating needs in winters. Over half of these provinces were also experiencing relatively slow GDP growth. For some provinces, such as Shanxi and Inner Mongolia, instead of energy intensity decreasing, it increased from 2015 to 2020 as their slow GDP growth failed to offset their rapid energy consumption (see Figure 2(B)).

However, failing to meet the energy intensity targets does not necessarily mean lagging behind in decarbonization. One of the challenges with the energy intensity target is that it doesn't consider energy mix, as it only measures total primary energy per unit of GDP. Some provinces that failed to meet the energy intensity target had significant growth in key sectors for decarbonization, such as renewable energy deployment. Guangxi is an example, which, despite not meeting its energy intensity target, achieved a non-fossil share of 26% in its primary energy mix by 2020, significantly exceeding the national target at 15.9%. Guangxi's energy CO2 emissions fell by 2% during the 13th FYP period while most provinces experienced an increase.

The main driver of this reduction was the power sector, as emissions were reduced by 17%, offsetting the emission increase in the industry sector. Similarly, energy CO2 emissions and energy consumption started to decouple in Chongqing, Beijing, Hainan, Qinghai, and Sichuan during the 13th FYP period. This suggests that energy intensity may not be an effective metric for evaluating emission reduction, especially for provinces that are further along in energy transition.

Emission Intensity

Under the 13th FYP, China has also made progress in emission intensity reduction. At the national level, China's emission intensity was reduced by 18.8% from 2015 to 2020, slightly exceeding the national 13th FYP target (of 18% reduction). At the subnational level, over half of the analyzed provinces met their provincial targets. Chongqing, Beijing, and Sichuan had the largest emission intensity reduction ranging from 42–46% compared to the 2015 level. By 2020, Beijing (as with energy intensity), had the lowest absolute emission intensity while Ningxia had the highest (see Figure 3(A)). Most of the provinces set targets that were more ambitious or the same as the national target, while Guangxi, Hainan, and Gansu, Qinghai, and Xinjiang set a lower target. All provinces had a target of at least 12% (see Table S1).

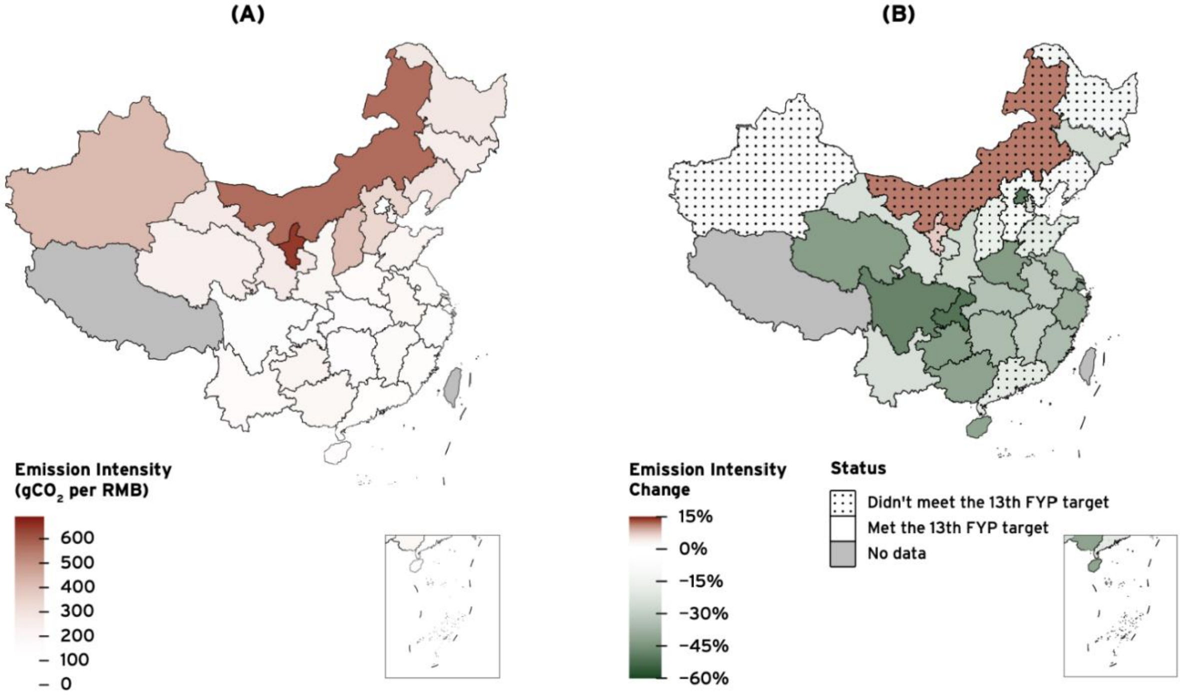


Figure 3. Emission intensity in 2020 and emission intensity change from 2015 to 2020. Map (A) shows the absolute emission intensity (gCO2 per RMB) by province in 2020. Map (B) shows the emission intensity change by province from 2015 to 2020. Provinces with dots did not achieve their provincial 13th FYP targets (or against the national 13th FYP targets if provincial targets are not specified). See Table S1 for detailed target level. Emission intensity is calculated based on methodology in Data and Methods and may differ from official claims. No data for Tibet, Taiwan, Hong Kong SAR, and Macau SAR.

Many of the provinces that did not achieve their targets had low GDP growth and/or increasing energy emissions (see Figure 4), similar to energy intensity. Shandong, Liaoning, Hebei, and Inner Mongolia had both low economic growth and high emission growth, indicating the need for integrated strategies that address both economic revitalization and emissions control. Provinces such as Tianjin and Heilongjiang maintained relatively low energy emissions growth but still fell short of emission intensity targets, underscoring the impact of GDP growth on intensity target success. Meanwhile, some provinces with high energy emissions growth, such as Shanxi, Xinjiang, and Ningxia, need to prioritize decarbonizing their energy system as energy emissions grew even faster than primary energy consumption in the 13th FYP.

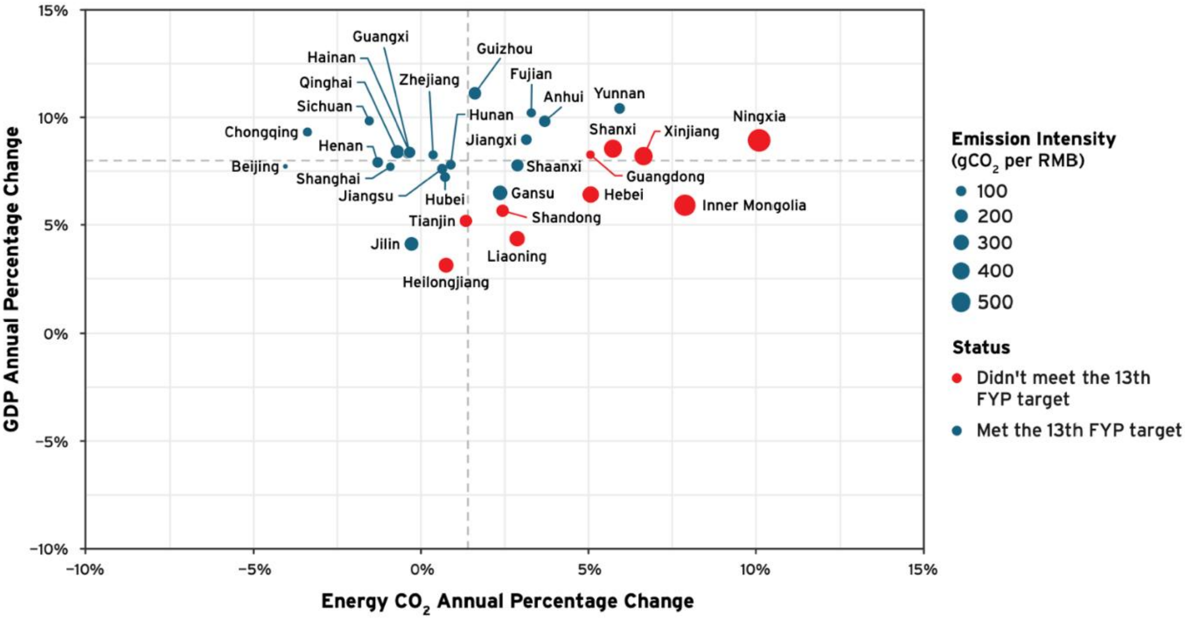


Figure 4. The annual percentage change of GDP and energy CO2 in 2020 compared to the 2015 level. The size of the dots represent the volume of absolute emission intensity (gCO2/RMB) by province in 2020. The dashed lines are national annual percentage change of GDP and Energy CO2 respectively. Provinces with red dots did not achieve their provincial 13th FYP targets (or national 13th FYP targets if provincial targets are not specified). See Table S1 for detailed target level. Emission intensity is calculated based on methodology in Data and Methods and may differ from official claims.

Relation Between Energy and Emission Intensity

Emission intensity reduction in the 13th FYP mostly aligned with energy intensity patterns. The provinces that achieved the greatest reductions in energy intensity also recorded the largest declines in emission intensity, vice versa (see Figure 5). However, in some provinces energy intensity and emissions intensity trends differed. The stage of energy system decarbonization plays an important role in the achievement of emissions intensity targets. Provinces such as Liaoning, Ningxia, Xinjiang, and Hebei met their 13th FYP energy intensity targets but did not achieve their emission intensity targets, likely due to limited decarbonization on the demand side (see Figure 5). Their non-fossil share of primary energy was lower than most other provinces, highlighting that reductions in emission intensity require shifts toward cleaner energy sources. In Shanxi, emission intensity decreased while energy intensity increased over the period, likely from coal-sector consolidation and power-plant retrofit efforts, echoing the importance of decarbonizing the power sector for achieving emission intensity reductions for most provinces. Guangdong also failed to meet the emission intensity target while achieving its energy intensity target. In 2020, 28% and 48% of the electricity demand in Guangdong was met by external imports, and fossil fuels from local power plants respectively. The low renewable penetration in the local power supply system led to continued emission growth despite its non-fossil share in primary energy consumption being above national level. Additionally, provinces with high GDP levels that are plateauing, such as Guangdong, will require enhanced actions to reduce emissions intensity (see Figure 4).

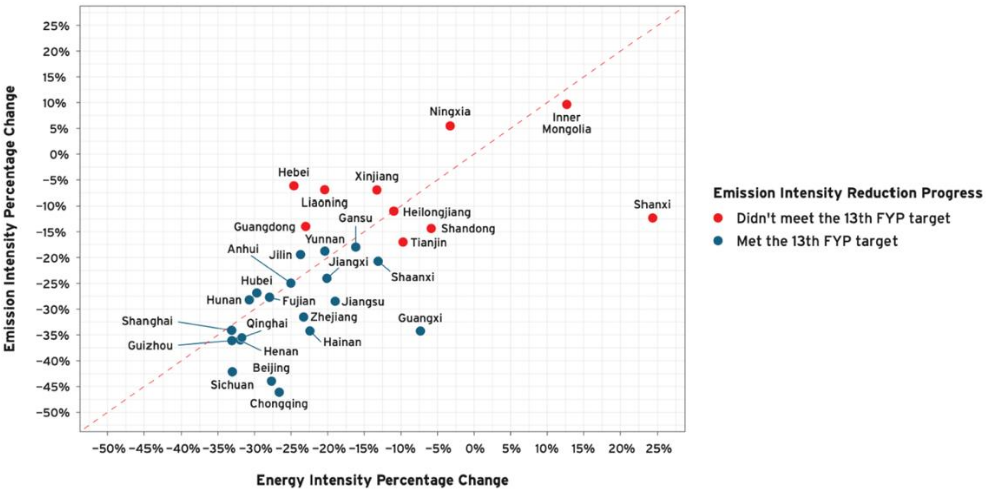


Figure 5. The percentage change of emission intensity and energy intensity from 2015 to 2020. Under the red dashed line, provinces have reduced emission intensity more than energy intensity. Provinces with red dots did not achieve their

provincial 13th FYP targets (or national 13th FYP targets if provincial targets are not specified). See Table S1 for detailed target level. Emission intensity is calculated based on methodology in Data and Methods, and may differ from official claims.

Recent Developments Under the 14th FYP (2021-2025)

Emissions data analyzed suggests that provinces may not be on track to meet their targets. By 2023, 26 out of the 30 analyzed provinces had not met their 14th FYP emission intensity targets based on the datasets used in this analysis (see Figure 6 and Table S2). Among the 26 provinces evaluated, 16 are not likely to meet the provincial 14th FYP emission intensity target if their emission trend from 2021 to 2023 continues through 2025. This aligns with other research indicating that China may fall short of reaching the national 14th FYP target for emission intensity by 2025.

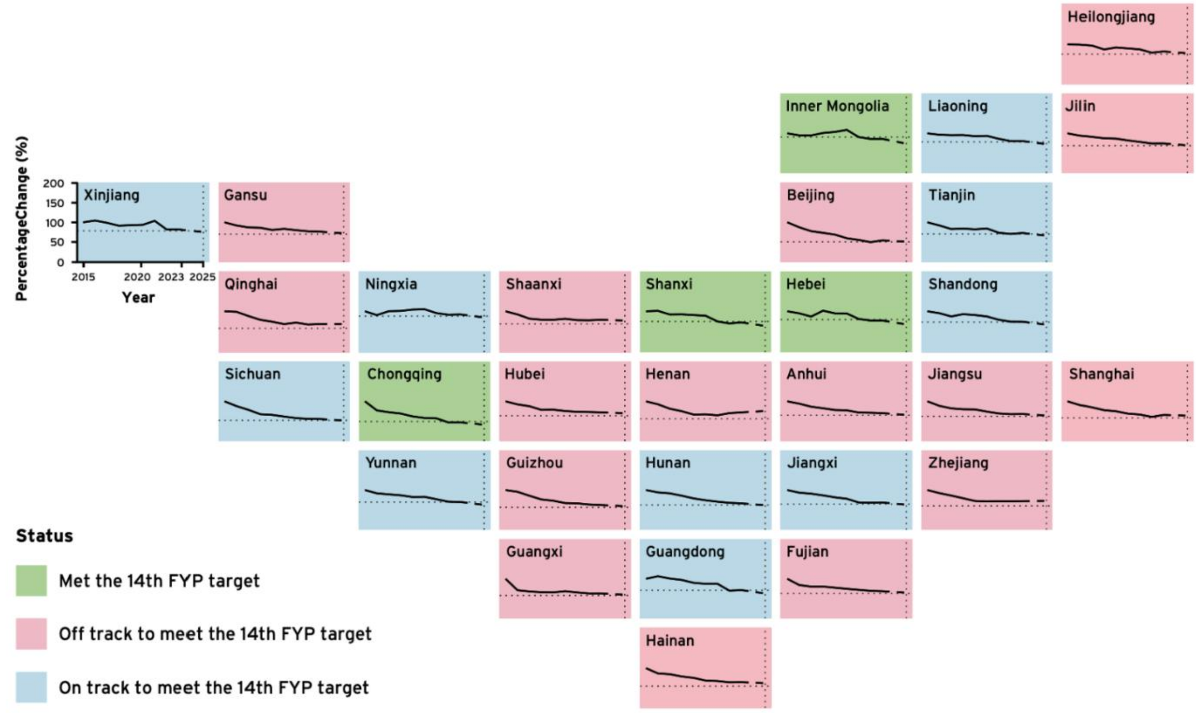


Figure 6. Emission intensity trend by province from 2015 to 2025. This figure arranges plots by the relative location of the analyzed provinces. The solid lines are indexed emission intensity trends from 2015 to 2023, with 2015 emission intensity as the baseline value in each provincial plot. The dashed lines are the indexed emission intensity from 2024 to 2025, which is the projected trend following the 14th FYP trend from 2021 to 2023. Emissions data in 2023 is projected based on the 2022-2023 emission growth from MEIC. The dotted horizontal and vertical lines in each province plot represent the target 2025 emission intensity in the 14th FYP. Provinces that reached the target by 2023 are defined as "have met the 14th FYP target." Provinces whose projected 2025 emission intensity level is lower than target are defined as "on track to meet the 14th FYP target." Otherwise, provinces are defined as "off track to meet the 14th FYP target." Emission intensity is calculated based on methodology in Data and Methods and may differ from official claims.

In the 14th FYP period, GDP is a key factor in emission intensity reduction in most provinces (see Figure 7). Provinces on track to meet or have met targets either offset high emissions growth with high GDP growth (Shanxi, Inner Mongolia) or have low emissions growth/decline with moderate GDP growth (Hebei, Beijing). Provinces where GDP growth does not exceed emission growth are not likely to meet the emission intensity target (Hainan, Shanghai). Additionally, most provinces have increasing emissions in the 14th FYP, reflecting the limitations of emission intensity targets. Energy CO2 emissions increased in most provinces between 2020 and 2023 (see Figure 8). Only three out of the 30 analyzed provinces – Chongqing, Hebei, and Guangdong – manage to reduce absolute energy emissions, and are on track or have already met their target (see Figure 7 and 8). As China advances toward its emission peaking stage (see Figure 8), introducing absolute emission targets at both the national and provincial level will be essential. Such targets help ensure that emission control is achieved independently from economic fluctuations and provide a more direct metric for managing real emission outcomes.

Provinces may want to adjust how targets are set, given the number of provinces that are off track to reach their 14th FYP targets. In contrast to the 13th FYP, most provinces did not establish specific provincial emission intensity targets for the 14th FYP period (2021-2025), instead aligning with the national goal of 18% reduction by 2025. Uniformed targets across provinces can signal a commitment to climate actions but can also discourage subnational actors from fully pursuing the target if viewed as infeasible. At the same time, setting up less ambitious targets does not necessarily mean a less significant reduction outcome. Gansu, Guangxi, Hainan, and Qinghai set emission intensity reduction targets lower than the national target under the 13th FYP. However, they all managed to meet or exceed the national reduction level by the end of the 13th FYP period (see Table S1).

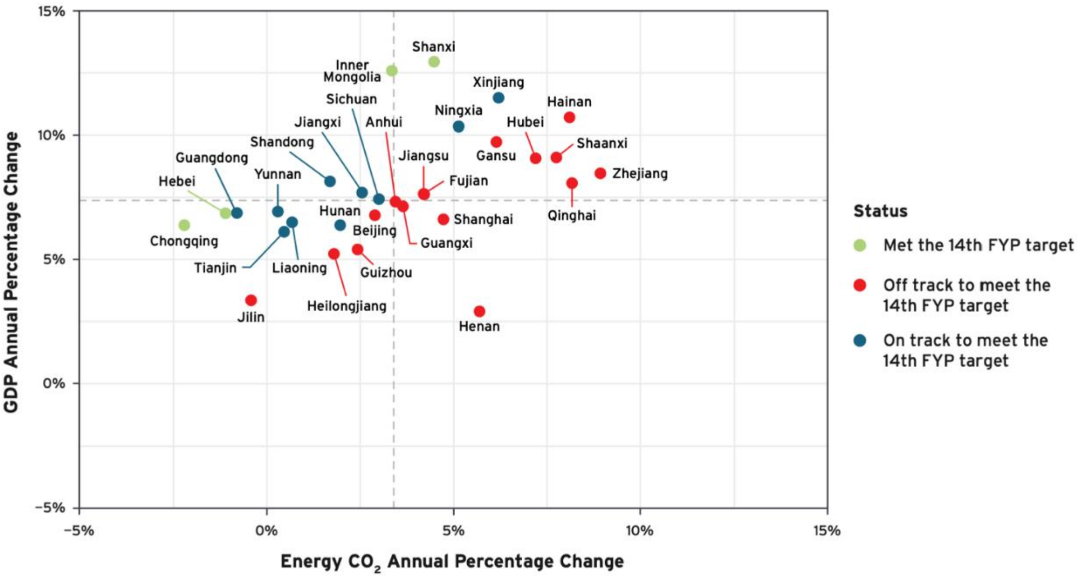


Figure 7. The annual percentage change of GDP and energy CO2 from 2020 to 2023. The dashed lines are provincial median annual percentage change of GDP and Energy CO2 respectively. Provinces that have reached the target by 2023 are defined as "have met the 14th FYP target." Provinces whose projected 2025 emission intensity level is lower than target are defined as "on track to meet the 14th FYP target." Otherwise, provinces are defined as "off track to meet the 14th FYP target." Emission intensity is calculated based on methodology in Data and Methods and may differ from official claims. 2025 emission intensity is projected based on the annual change rate from 2021 to 2023.

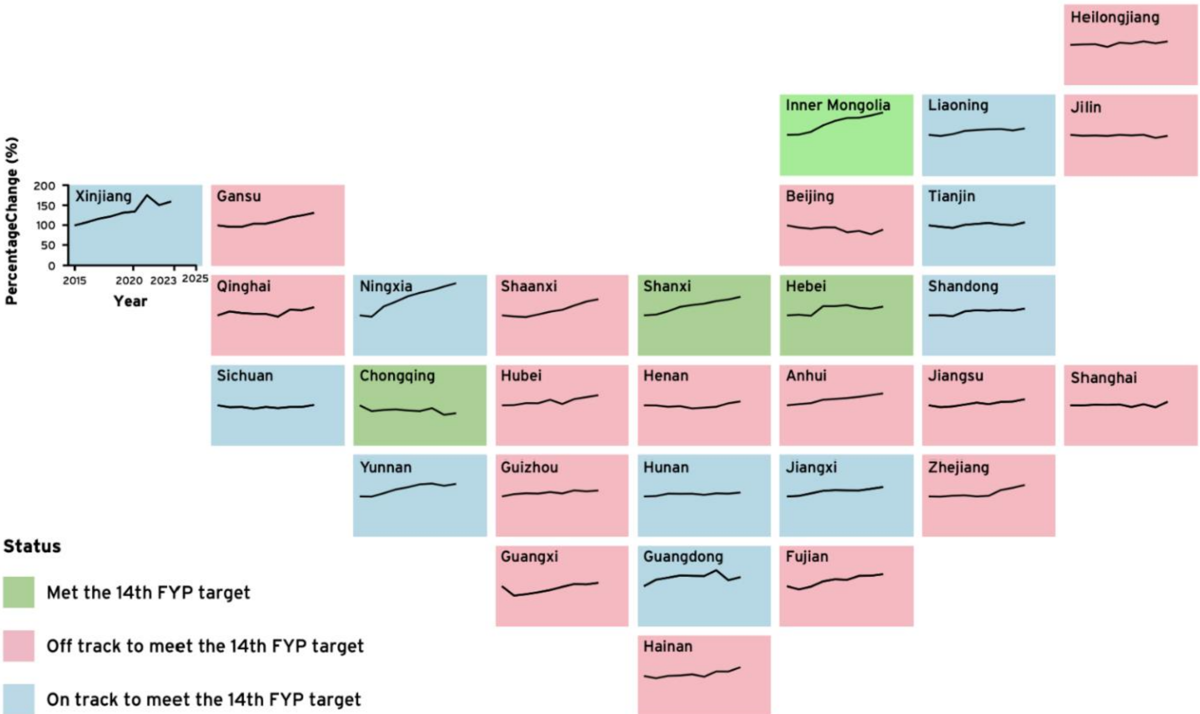


Figure 8. Total emissions trend by province from 2015 to 2023. This figure arranges plots by the relative location of the analyzed provinces. The lines are indexed emission trends from 2015 to 2023, where 2015 emission is the baseline value in each provincial plot. Provinces that have reached the target by 2023 are defined as "have met the 14th FYP target." Provinces whose projected 2025 emission intensity level is lower than target are defined as "on track to meet the 14th FYP target." Otherwise, provinces are defined as "off track to meet the 14th FYP target." Emission intensity is calculated based on methodology in Data and Methods and may differ from official claims.

Entering the 15th FYP (2026-2030)

As China enters its peaking period, this transitional moment is critical for shifting from an energy-focused and GDP intensity framework to one centered on emission control. Both national and provincial governments are actively engaged in formulating the action plans to introduce dual carbon control. Provincial energy and emission trends vary as they are at different stages of decarbonization, reflecting China's present and future transition pathways. Evaluating these trends can help to inform national strategy setting in the upcoming era.

While energy and emissions started to decouple in some provinces, reducing energy demand is still critical for emissions control, especially for provinces in early stages of energy transition. In most cases, emissions reduction is still driven by lowering energy consumption levels (see Figure 5). Energy efficiency is especially critical for northern provinces that still have difficulty meeting their energy intensity targets. Key actions include accelerating industrial and building electrification with high-efficiency equipment, tightening efficiency standards, and deploying digital energy management systems. The electrification in the industrial and building sector can also facilitate decarbonization in regions dominated by energy-intensive and emission-intensive industries. Demand-side management, such as time-of-use pricing and virtual power plants, can shift consumption away from peaks and reduce the need for new capacity. Allowing efficiency and load flexibility in power markets can drive demand reduction and decarbonization. Power sector reforms will be a synergy among the central and provincial government, private sector, and financial sector. National agencies set the regulatory framework and market rules, while provincial governments implement pilot markets and adapt policies to local conditions. Grid and renewable facility providers are supported by financial institutions that fund the efficiency retrofits as a revenue-generating resource.

Expanding clean energy deployment through policies at both the national and provincial level is needed to reduce emissions from remaining energy uses. Provinces such as Guangxi demonstrate that rapid renewable deployment can decouple energy consumption from emissions (see Figure 5). This pattern is expected to characterize China's broader decarbonization trajectory in the future. The new dual emission control highlights the importance of renewable energy expansion along China's carbon neutrality pathway and eases the previous pressure of strict energy consumption caps. Under this framework, energy use can continue to rise but is supported by low-carbon power sources such as solar and wind. Meanwhile, renewable expansion introduces challenges, including regional differences in resource endowment and grid reliability. Coal-dependent areas like Shanxi face greater structural challenges in diversifying their energy mix. Moreover, large-scale renewable integration will require substantial investment in energy storage, grid modernization, and interregional transmission, balancing supply variability and ensuring stable power delivery. Expanding clean energy and its supporting infrastructure can not only accelerate decarbonization but also drive economic development by opening up new avenues for investment, which can also help ease the pressure of meeting emission intensity targets. In this case, at both national and provincial levels, more detailed and measurable targets such as renewables and storage buildout, and advancing renewable integration to power grids will be benchmarks to evaluate China's progress and next steps in decarbonization.

In the 15th FYP period, it will be increasingly important to develop overall total emission control strategies through pilot cases and coordination. While the announced national 15th FYP targets remain intensity-based, the policy focus shift from emission intensity to total emission control is possible since China is going to reach at least a plateau stage in emissions (see Figure 8). Additionally, as China for the first time included the economy-wide greenhouse gas (GHG) reduction target in its 2035 NDC, implementing absolute emission targets in the FYPs and at the provincial level will help achieve national goals. Focusing on absolute emission levels, rather than relative to GDP growth, increases transparency for national and provincial targets, helping to accelerate the transition. Provinces such as Shanxi and Xinjiang will face difficulties as their emission intensity reduction has relied on their GDP growth instead of absolute emission reduction. It is important for them to develop a low-emission economy under tailored sectoral transition plans. As policy focus shifts to total emission control, provinces such as Hebei and Chongqing that already have low-carbon economic development (see Figure S1) could serve as pilot regions, offering valuable experience and best practices as China approaches its national carbon peak and prioritizes total emissions control. The central government can play a leading role in facilitating this process by encouraging provinces that are further along in the energy transition to assist others in designing viable implementation strategies and knowledge sharing.

Overall, the diverse provincial contexts suggest tailored and attainable provincial targets both for emission intensity and absolute emission control. In provinces like Jilin and Heilongjiang, where GDP growth remains below the national median (see Figure 4), lower intensity targets can help avoid undue pressure arising from slower economic expansion. For provinces and regions with already low absolute emission intensity, such as Guangdong (see Figure 4), reducing absolute emissions will be their provincial priority before the policy transition at the national level. When China transitions national priority to absolute emission control after the peaking, differentiated provincial targets remain important because provincial capacity to reduce emissions varies. In the 14th FYP, only four out of 30 analyzed provinces managed to reduce their absolute emissions by 2023 (see Figure 8). Moreover, it is essential that both provincial and national targets are grounded in socioeconomic contexts, accurately reflecting China's progress in decarbonization. The current 14th FYP uses 2020 as the baseline year, a period marked by unusually low emissions due to the pandemic, which risks distorting the evaluation and may be impacting whether provinces achieve the target.

Conclusion

China is entering a critical phase in its climate transition. China's emissions are likely peaking, and in several provinces, emissions are now beginning to decouple from energy consumption as the clean energy transition expands. Climate governance is now shifting from an energy-focused framework toward one centered on emission intensity and, ultimately, total emissions control. Evaluating provincial trends in energy intensity, emission intensity, and total emissions provides not only a glimpse into where each province stands in the transition, but also a roadmap for provincial and national policy design under this evolving governance structure.

Provincial performance in emission intensity reduction, which serves as the main metric in the 15th FYP, can continue benefiting from energy management and further decoupling of energy consumption and emissions through renewable expansion. Preparing for total emissions control is essential to ensure meaningful reductions for 2035 NDC targets through accelerated provincial actions in China's post-peaking era. To secure China's climate commitment and economic development, it is important to maintain economic development throughout decarbonization by more low-carbon economy strategies.

Provinces are progressing through the energy transition at different speeds, shaped by economic structure, resource endowment, industrial composition, and development stage, and require varied and adaptive approaches for policy setting. Differentiated and adaptive provincial targets, balancing ambition with feasibility, can enhance effectiveness and equity. Cross-provincial coordination and knowledge sharing will be vital for scaling successful strategies and accelerating learning.

Together, these insights underscore a key message that China's transition toward an emissions-focused governance framework marks a pivotal evolution in national and provincial climate strategy, and its success will depend on targeted provincial action, flexible policy design, and coordinated national leadership.

Appendix

Table S1. Emission intensity by province in 2020, the reduction rate compared to the 2015 level from this policy brief analysis and official reports, and the provincial targets for emission intensity reduction. Provinces that didn't meet the provincial emission intensity reduction target in the 13th FYP are colored in red.

Province	Emission intensity (gCO_2 / RMB)	Change in Emission intensity (2015-2020)*	Official claims of change in emission intensity (2015-2020)	Target provincial emission intensity reduction (2015-2020)
Anhui	98.5	-25%	-22.07%[34]	-18%
Beijing	21.1	-44%	>-26%[35]	-20.5%
Chongqing	53.5	-46%	-21.88%[36]	-19.5%
Fujian	56.1	-28%	about -20%[37]	-19.5%
Gansu	180.8	-18%	-28%[38]	-17%
Guangdong	46.3	-14%	-22.35%[39]	-20.5%
Guangxi	105.2	-34%	NA	-17%
Guizhou	124.0	-36%	NA	-18%
Hainan	62.7	-34%	-24% (2015-2019)[40]	-12%
Hebei	251.4	-6%	>-25%[41]	-20.5%
Heilongjiang	195.2	-11%	-20.50%[42]	-18%
Henan	81.0	-36%	-28%[43]	-19.5%
Hubei	66.4	-27%	-24.47%[44]	-19.5%
Hunan	64.2	-28%	-19.80%[45]	-18%
Inner Mongolia	480.5	10%	13.86%[46]	-17%
Jiangsu	71.0	-28%	-24%[47]	-18%

Province	Emission intensity (gCO_2 / RMB)	Change in Emission intensity (2015-2020)*	Official claims of change in emission intensity (2015-2020)	Target provincial emission intensity reduction (2015-2020)
Jiangxi	82.7	-24%	-22.25%[48]	-19.5%
Jilin	158.9	-19%	-25.24%[49]	-18%
Liaoning	211.2	-7%	-11.62% (2015-2019)[50]	-18%
Ningxia	554.9	5%	-14.75% (2015-2019)[51]	-17%
Qinghai	147.5	-36%	-43%[52]	-12%
Shaanxi	111.5	-21%	-20.8% (2015-2019)[53]	-18%
Shandong	120.8	-14%	>-22.7%[54]	-20.5%
Shanghai	45.9	-34%	NA	-20.5%
Shanxi	317.9	-12%	NA	-18%
Sichuan	53.8	-42%	-29.90%[55]	-19.5%
Tianjin	114.3	-17%	-23%[56]	-20.5%
Xinjiang	329.8	-7%	NA	-12%
Yunnan	80.6	-19%	-24.72%[57]	-18%
Zhejiang	53.9	-32%	18.45% (2015-2019)[58]	-18%

* Calculated based on methodology in Data and Methods. Results can differ from official claims due to different data sources and accounting approaches.

Table S2. Emission intensity change from 2015 to 2023, target change from 2015 to 2025, and the provincial 14th FYP target for emission intensity reduction. The target emission intensity change from 2015 to 2025 is calculated based on the emission intensity change from 2015 to 2020 and the provincial 14th FYP target. Provinces that haven't met the 14th FYP target for emission intensity reduction by 2023 are colored in red.

Province	Change in Emission Intensity (2015-2023)*	Target Change in Emission Intensity (compared to 2015 level)	14th FYP Target (compared to 2020 level)
Anhui	-33%	-38%	-18%
Beijing	-50%	-54%	-18%
Chongqing	-58%	-56%	-18%
Fujian	-34%	-41%	-18%
Gansu	-26%	-33%	-18%
Guangdong	-31%	-32%	-20.5%
Guangxi	-40%	-46%	-18%
Guizhou	-41%	-48%	-18%
Hainan	-39%	-49%	-23%
Hebei	-26%	-23%	-18%
Heilongjiang	-19%	-27%	-18%
Henan	-31%	-48%	-19.5%
Hubei	-31%	-40%	-18%
Hunan	-37%	-41%	-18%
Inner Mongolia	-15%	-10%	-18%
Jiangsu	-35%	-41%	-18%
Jiangxi	-34%	-39%	-19.5%

Province	Change in Emission Intensity (2015-2023)*	Target Change in Emission Intensity (compared to 2015 level)	14th FYP Target (compared to 2020 level)
Jilin	-28%	-34%	-18%
Liaoning	-21%	-24%	-18%
Ningxia	-9%	-14%	-18%
Qinghai	-35%	-47%	-18%
Shaanxi	-24%	-35%	-18%
Shandong	-29%	-30%	-18%
Shanghai	-38%	-46%	-18%
Shanxi	-31%	-28%	-18%
Sichuan	-49%	-53%	-18%
Tianjin	-30%	-32%	-18%
Xinjiang	-20%	-24%	-18%
Yunnan	-33%	-33%	-18%
Zhejiang	-31%	-44%	-18%

* Calculated based on methodology in Data and Methods. Results can differ from official claims due to different data sources and accounting approaches.

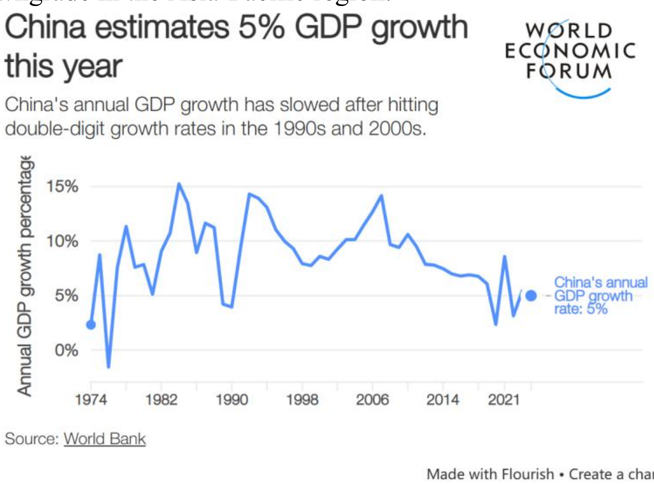
IMI International Monetary Review

How China Built the Energy System the World Now Needs

By KAISER KUO [*]

The conflict that erupted at the end of February 2026 was, among other things, an energy shock. Nine weeks of disruption in and around the Strait of Hormuz pushed Brent to nearly $120 a barrel, sent liquefied natural gas (LNG) prices to multi-year highs, and forced governments to confront the fragility of supply chains they had spent the post-COVID years assuming were secure. The shock exposed which economies had built genuine resilience into their energy systems, and which had merely diversified their suppliers of imported hydrocarbons.

On paper, China should have been among the most exposed economies. Columbia's Center on Global Energy Policy has noted that roughly 45-50% of its crude imports transit Hormuz, and nearly a third of its LNG comes from the Gulf. But China's economy proved considerably more insulated than those numbers would predict. Goldman Sachs trimmed its 2026 growth forecast for the country by only 0.2 percentage points – the smallest downgrade in the Asia-Pacific region.



Part of that cushion was conventional: a strategic and commercial crude stockpile of some 1.2 billion barrels, enough to run the country for over 100 days with zero imports, and supply lines diversified toward Russia, Central Asia and other non-Gulf sources. But the deeper reason is that the marginal growth in energy demand over the last decade has been met not by more imported oil but by domestically generated electricity.

Transport electrification has converted what would have been gasoline demand into power demand. Rhodium Group estimates that China's electric-vehicle fleet alone now displaces over 1 million barrels per day of oil demand, "equivalent to roughly the daily oil production of Oman.". Industrial electrification is beginning to do the same in steel, cement and chemicals – the hard-to-abate sectors where progress has been slowest globally, but where Chinese firms have made measurable headway. The grid build-out, especially the network of ultra-high-voltage transmission lines that move electricity from the wind and solar resources of the west to the load centres of the east, enables domestically generated power to reach the places that need it. China's structural exposure has been shrinking for years.

The Hormuz shock has also accelerated something that was already underway: a global reframing of the energy transition from a climate question into an energy-security question. But how did a single country come to occupy the position from which it could better absorb a shock of this magnitude than many other nations?

No one foresaw this moment. But the system that has absorbed it relatively well was the product of sustained planning and sustained pressure – of bets that Chinese policy-makers made deliberately and of responses to problems they had not chosen and could not have wished for. The compounding of the two, over a quarter-century, produced what the rest of the world now needs.

Chokepoint vulnerability and an emerging security strategy

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China's Five-Year Plans have included renewable energy development goals since the 10th Five-Year Plan (2001-2005). Since then, the plans have continued to play a crucial role in setting priorities for officials and enterprises. But it would be a mistake to overstate the role of contingency and improvisation: the Chinese position in the energy transition was also the product of a confluence of pressures, decisions and capacities that compounded over roughly a quarter-century, during which any number of different choices could have been made, and several of them very nearly were.

The catalysing pressures arrived in the early 2000s, and they were about energy security well before they were about climate. China's oil import dependence, near zero in the early 1990s, crossed 40% around 2003 and kept climbing. The country was already importing through the Strait of Malacca, the Strait of Hormuz, and the South China Sea; Chinese strategic planners were beginning to articulate what came to be called the "Malacca dilemma" – the recognition that an enormous and growing share of the country's energy supply transited a chokepoint controlled by potentially hostile naval powers.

During the same period, electricity demand outpaced generation capacity. Brown-outs and load-shedding became routine in major coastal provinces in 2003 and 2004 as the coal transport infrastructure creaked under surging demand. The SARS outbreak compounded the sense that the system's margins were too thin. Out of this period came a series of decisions whose consequences would not be fully visible for 15 years: a commitment to ultra-high-voltage transmission as a national grid backbone, the establishment of the National Energy Administration's institutional predecessors, and the early framework for what would become a sustained policy of moving electricity from interior generation to coastal consumption.

The conclusion Chinese planners eventually drew from the chokepoint vulnerability was to reduce the dependency itself. The country could not realistically power its rapid economic growth and achieve hydrocarbon self-sufficiency the way the United States did through shale; its endowment was too thin and its consumption too large. What it could do was build the manufacturing base and the grid that would let domestically generated electricity displace imported oil and gas in transport and industry over time. The Chinese transition turned out to be a security strategy that was incidentally a climate strategy.

Beijing's "airpocalypse"

The second pressure was air pollution, which became politically unignorable in the late 2000s and the early 2010s. Beijing's airpocalypse of January 2013, when PM2.5 readings broke the upper limit of the US Embassy monitor, was the visible apex of a problem that had been building for years. The political response was real and consequential. Coal-fired industrial boilers were phased out in dense urban regions and replaced by electrified or gas-fired alternatives. Emission standards on power plants were tightened to levels that, by the late 2010s, exceeded those in force in US. Particulate concentrations in major cities have since fallen sharply – by 41% nationally between 2013 and 2022.

To be sure, the pollution problem is not solved. But the crisis did something else as well: it gave the public a stake in the energy transition that was immediate and tangible, in a way that long-horizon climate arguments rarely do. People in Chinese cities could feel, on their skin and in their lungs, what cleaner energy meant.

2008 financial crisis and 'new infrastructure' investment

The third pressure was the 2008 financial crisis and the 4 trillion yuan stimulus that followed. These measures are remembered in the West primarily for their excesses in real estate and heavy industry, but a significant share was directed into renewable energy capacity, grid infrastructure and what would later be called the "new infrastructure" categories. The investment pushed Chinese solar and wind manufacturing onto the steep part of its learning curve at exactly the moment the global market was contracting.

The energy evolution

The fourth pressure came from the leadership itself. In June 2014, Xi Jinping delivered a speech to the Central Financial and Economic Affairs Commission that introduced what came to be known as the "Energy Revolution" – a four-part formulation calling for revolutions in consumption, supply, technology, and institutions, with international cooperation as a fifth element. The speech matters less for any specific policy it announced than for what it signalled: that energy was now a top-leadership concern, rather than a sectoral matter handled by line ministries.

That framing has held. In September 2020, Xi announced at the United Nations General Assembly that China would peak its carbon emissions before 2030 and reach carbon neutrality before 2060. The 14th Five-Year Plan, released the following year, began the institutional work of translating that target into operational targets across ministries, provinces and state-owned enterprises, including the consequential shift from controlling energy consumption to controlling carbon emissions.

What looks in retrospect like a coherent trajectory was, in real time, a sequence of pressured responses to immediate problems – energy insecurity, air pollution, and post-crisis demand for stimulus. The system that resulted was the product of those alignments, not of perfect foresight.

The market that had to be made

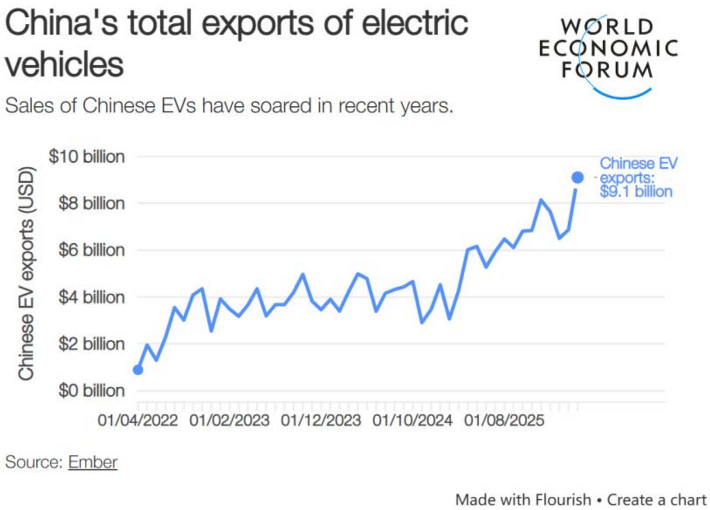
Most cleantech in 2005, 2010, or even 2015 had no natural market. The cost curves for solar, wind and lithium-ion batteries were still descending from levels that made unsubsidized deployment uneconomic in most applications. Electric vehicles were an off-puttingly expensive niche product. The technologies existed, often in forms perfected by Western and Japanese firms, but the demand to absorb them at scale did not.

A market for clean technology had to be built – by policy, by procurement, by regulation that priced out the incumbent – before the technology could reach volumes that would bring costs down to the point where it could compete on its merits. This is what Western coverage of Chinese industrial policy most often misses. It is also what sets the Chinese approach to energy security apart from most other large economies. The conventional response to import dependence is to make the imports themselves more secure: diversify the suppliers, build strategic reserves, protect the sea lanes, secure oil supplies. China did all of that, but the larger bet was on the demand side. If the economy ran increasingly on electricity generated at home, the reliability of any given shipping lane would weigh less on it each year.

The tools were varied and, taken individually, unremarkable. Most had analogues elsewhere. What was distinctive in China was their accumulation and the willingness to apply them across multiple cleantech sectors at once.

EVs and the dual credit system

For electric vehicles, the most consequential tool was the dual-credit system introduced in 2017, which required automakers to produce and sell a rising share of new energy vehicles or buy credits from competitors who exceeded their quotas – a mechanism modelled directly on California's Zero-Emission Vehicle programme. Tier-one cities reinforced the pull by tying license-plate access to EV ownership: In Beijing, where internal-combustion plates were rationed by lottery, EV buyers could obtain plates with significantly less wait time; in Shanghai, where plates were auctioned at prices around 90,000 yuan, EV buyers were exempted from the auction. Public charging infrastructure was rolled out by the Big Five state power generators under explicit central direction, with State Grid Corporation alone committing to install hundreds of thousands of charging points by the early 2020s – a public investment that closed the range-anxiety gap that had deterred private buyers from EVs through the early 2010s.



Solar and wind: construction of demand

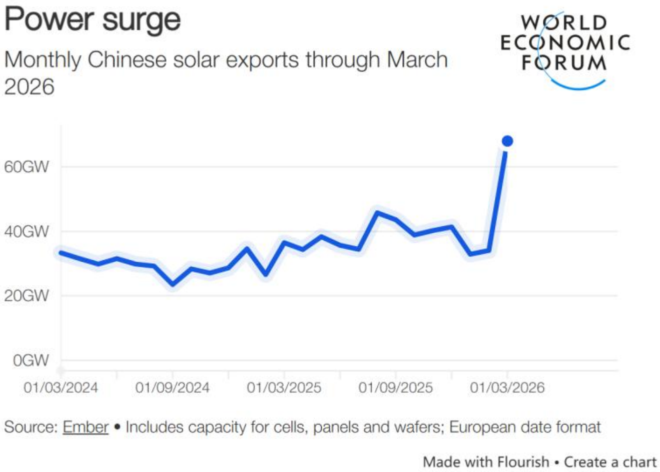
For solar, the Golden Sun programme of 2009 and the feed-in tariff regime that followed in 2011 provided guaranteed offtake at administered prices, giving developers the revenue certainty needed to deploy at scale through the period when generation costs still exceeded grid parity.

For wind, the early concession-tendering rounds and the 2005 renewable energy law established mandatory grid-purchase obligations that converted intermittent generation into a viable commercial proposition.

Across all these instruments, the common feature was the construction of demand at administered terms long enough for the supply side to reach scale, after which the administered terms could be wound back as cost curves did the rest.

What the demand created was a supply side that, within a decade, became the most cost-disciplined and vertically integrated clean-technology manufacturing base in the world. The pattern was visible across sectors but clearest in batteries. CATL, founded in 2011 in Ningde, scaled from a battery supplier to a single domestic automaker into the dominant global producer of lithium-ion cells in under a decade, helped by an early partnership with BMW. BYD took a different route, using its battery-making heritage as a structural cost advantage that competitors could not replicate. By the early 2020s, these two firms together accounted for over half of global EV battery production.

The competition that produced this position was, by most accounts, brutal. Profit margins among Chinese cleantech firms have run consistently lower than those of their Western and Korean competitors. The same dynamic is now playing out in EVs, where domestic competition among more than a hundred EV brands is widely expected to produce a similar shakeout.



The grid story: supply side - but also demand

The spine of that system is ultra-high-voltage transmission. The technology, developed at scale almost nowhere else, lets electricity move at very high voltages and very low losses over continental distances. China made an early commitment to UHV in the mid-2000s and has since built a network that connects the wind and solar resources of the western and northern provinces – Inner Mongolia, Xinjiang, Gansu, Qinghai – to the load centres of the eastern coast. The engineering is unforgiving. The country's longest UHV line, the 1,100-kilovolt Changji-to-Guquan link, runs more than 3,200 kilometres and can transmit 12 gigawatts – enough to power 50 million households – at loss rates that make transmission across such a distance economically viable.

Variable renewables present an integration problem that grids designed for dispatchable thermal generation handle poorly. Curtailment – generation produced but not absorbed by the grid – ran painfully high in the wind-rich north-west in the early 2010s, with rates above 30% in some provinces. The response combined transmission build-out, dispatch reform, and market mechanisms that priced curtailment into generators' returns. The IEA reports that Chinese curtailment fell from 16% in 2012 to less than three per cent by 2022, enabled by what it calls "large-scale investment in grid infrastructure" averaging $75 billion per year. The integration problem is not solved, but the trajectory is one of an integration challenge being managed in real time rather than outpacing policy.

The demand side of the grid story has had less attention than the supply side, but the latter is structurally the more interesting half. Electrification has not been confined to passenger cars. China's intercity rail network, the world's largest, is more than 75% electrified. Fifty-four cities have built subway systems totaling nearly 11,000 kilometres, almost all of which were built since 2000. More than 400 million electric two-wheelers have replaced the two-stroke gasoline scooters that fueled urban air pollution across much of the developing world. Marginal energy demand in Chinese cities is met by electricity from a grid steadily shifting toward non-fossil sources, rather than by imported gasoline and diesel. Whether the system has reached the point of producing an absolute emissions decline, or only the slowing of their growth, is the question that now matters.

The trajectory now: have renewables grown fast enough to bend the emissions curve?

The course corrections have been real. A power crunch in 2021 slowed the pace at which coal was retired, and the oft-cited surge in new coal-power approvals in 2022 and 2023 reflected an explicit reprioritization of energy security.

Speaking at the Xiong'an headquarters of Huaneng Group in March 2026, Xi insisted that coal-fired power remained "the foundation of our energy supply" and would "continue to play a backstop role" even as the system pivoted toward renewables. This looks at first glance like a contradictory picture – China being simultaneously the world's largest builder of renewables and the world's largest builder of new coal capacity. Both reflect the same underlying strategy.

The more interesting question is whether the renewables line has now grown fast enough to bend the emissions curve. The data through early 2026 suggests it has, and that this plateau is different in kind from the ones before it.

China's emissions have fallen four times in the past four decades, but every previous decline was the by-product of economic weakness: the industrial slump of 2015, the zero-COVID contraction of 2022. Demand fell, so emissions fell. What began in March 2024 is the opposite. Lauri Myllyvirta of the Centre for Research on Energy and Clean Air, whose quarterly analyses for Carbon Brief are the standard reference on Chinese emissions, reports that the country's CO_2 emissions have now been flat or falling for 21 months as of February 2026 – not because demand stalled, but because clean-power generation has been growing faster than demand. Myllyvirta's February analysis found a result with no modern precedent: In 2025, coal-fired power generation in China fell for the first time in over half a century, even as the economy kept expanding.

Whether this is the peak is a different question. Emissions remain only slightly below the previous high, which means a single bad quarter for renewables – a dry year for hydropower, a slowdown in capacity additions, a surge in chemical-industry coal use – could push the headline emissions number to a new record. And the 15th Five-Year Plan, released in March 2026, has been criticized by Myllyvirta and others for setting a carbon-intensity target that, under a revised methodology, could permit absolute emissions to rise three to six per cent over the next five years.

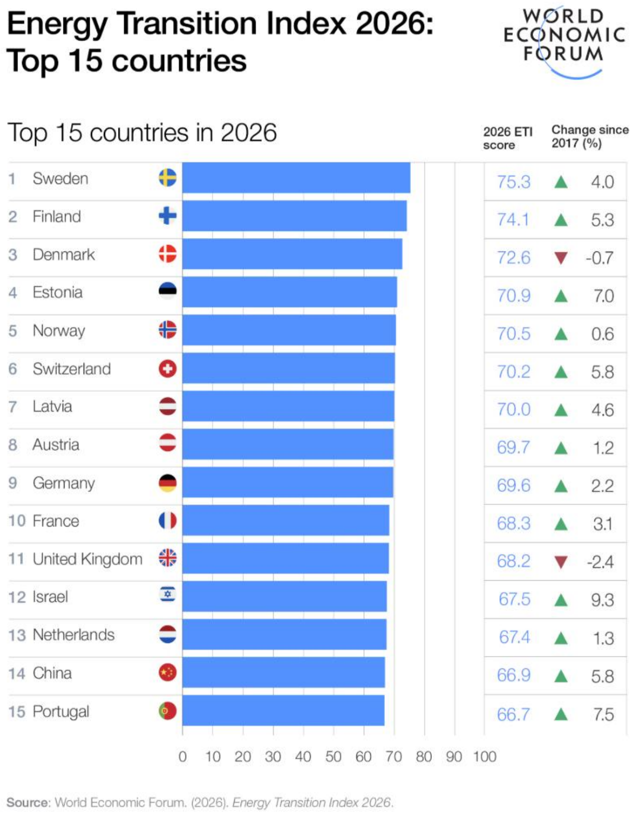
But the plateau is nonetheless real. The system is now capable of producing an absolute emissions decline. Whether the policy framework will allow it to is the open question.

A replicable story for other countries?

The temptation is to draw the wrong lesson from this story: that other countries should copy the Chinese model. They cannot.

"China's energy transition demonstrates the power of long-term planning," says Espen Mehlum, Head of Energy at the World Economic Forum. "Guided by successive Five-Year Plans, the country has improved energy security, sustainability and affordability while reducing import dependence and local air pollution.

"In parallel, it has built globally leading capabilities in clean energy industries such as electric vehicles, batteries and solar manufacturing – progress reflected in its strong performance in the World Economic Forum's Energy Transition Index."



China sits at 14th on the 2026 Energy Transition Index — among the largest gainers in the top tier, up 5.8 points since 2017. Image: World Economic Forum

The Chinese trajectory was made possible by a specific institutional configuration: a state with the planning horizon to make 20-year infrastructure commitments, the fiscal capacity to absorb a decade of thin margins in strategic industries, the bureaucratic reach to align provincial incentives with national targets, and the political stability to weather repeated course corrections without abandoning the underlying direction. Few other nations possess this, and no liberal democracy is going to acquire it by importing a five-year plan.

What to build domestically and what to source

The right lesson is different. The energy transition demands certain capacities, and those capacities can be sourced through different institutional means. China sourced them through a particular form of state-directed capitalism. Norway and Costa Rica achieved high EV adoption without industrial policy at all – by using simpler tax and import mechanisms in countries small enough that domestic production was never the goal. California pioneered the credit system that China later adapted, and continues to lead US clean-energy policy through state-level regulation that the federal government has not matched. The European Union is pursuing a managed engagement model in which Chinese firms invest in European production under terms that include technology transfer. India is building its own clean-tech base by combining domestic incentives with selective sourcing from Chinese suppliers. Brazil is positioning itself as a destination for Chinese investment that brings manufacturing capacity rather than raw-material extraction.

Each of these is a recognizable response to the same structural facts: The cost of clean technology has fallen far enough to compete on merits, the supply chain runs largely through China, and the strategic question is what to build domestically and what to source.

The energy transition is no longer a climate question

The harder lesson, for countries that have spent the past decade treating the energy transition primarily as a climate question, is that it is now also a security question – unmistakably so after the Iran shock.

While the two framings can sometimes produce win-win outcomes, they can also produce different politics. A country that wants energy independence in 2026 can plausibly build toward it through electrification, but the path may run through Chinese supply chains in the medium term, producing dependency challenges. A country that frames the transition primarily as a contribution to global decarbonization tends to find its political coalitions narrower and its policy horizons shorter. Whether the shift towards security produces durable policy in the US, the EU and the major emerging economies is the question the rest of this decade will answer.

After Iran

The Chinese system that absorbed the Iran shock was not designed to absorb it. It was built, over a quarter-century, in response to pressures that were mostly local and mostly immediate: an oil-import dependency that had become strategically uncomfortable, an electricity grid that could not keep up with industrial demand, an air pollution crisis that had become politically unsustainable, a stimulus moment that needed somewhere to go, and a leadership that came to treat energy as a top-tier concern.

But ad hoc though China's energy strategy may have been, the Iran situation revealed the value of a second kind of security the country had been accumulating. This is the security that comes from grids able to move power across the distances China spans, from factories that turn out panels, batteries, and transformers in the volumes the transition demands, and from the engineering depth to build all of it faster than politics can dictate alone. An economy with those capacities bends under an oil shock. An economy without them breaks. China didn't set out to build any of this for a conflict in the Gulf. It was built by solving other problems over 25 years. 2026 was just the moment the rest of the world noticed what it had.

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China's Energy Fortress Was Built to Withstand just This Type of Oil Shock

By SIMONE MCCARTHY

For more than a decade, leader Xi Jinping has overseen a transformation within the Chinese economy with one aim: making it energy-secure.

Under that vision, China has unleashed a renewable energy revolution of wind, solar and hydropower, drilled ever deeper into oilfields offshore and on, and forged pacts with partners for more supply – all in a bid to cut the country's reliance on imported fuel and insulate it against "external shocks."

Now, the historic oil crisis triggered by the United States and Israel's war on Iran is posing the sternest test to date of China's Promethean effort toward energy self-sufficiency. It's a test that China appears to be passing.

While fuel-strapped countries across Asia have scrambled for supplies, China – the world's largest energy importer – has been sitting on vast stockpiles of oil, an industrial sector largely run on domestic energy and a fleet of cars increasingly powered by electricity, not gas.

For China, the ability to weather the energy shocks from the weeks-long war "is sort of a vindication of everything they've done to enhance energy security," said Erica Downs, a senior research scholar at the Center on Global Energy Policy at Columbia University.

"There's a lot they can look back on and say, 'We made the right call.'"

That vindication for China comes at a time when the US has retreated from its push into renewable energy and electric vehicles – creating a steep divergence between the models of the world's two leading economies when it comes to power.

Electrostate

Since becoming a net importer of energy in the early 1990s, China has seen its reliance on the Middle East as a dangerous vulnerability.

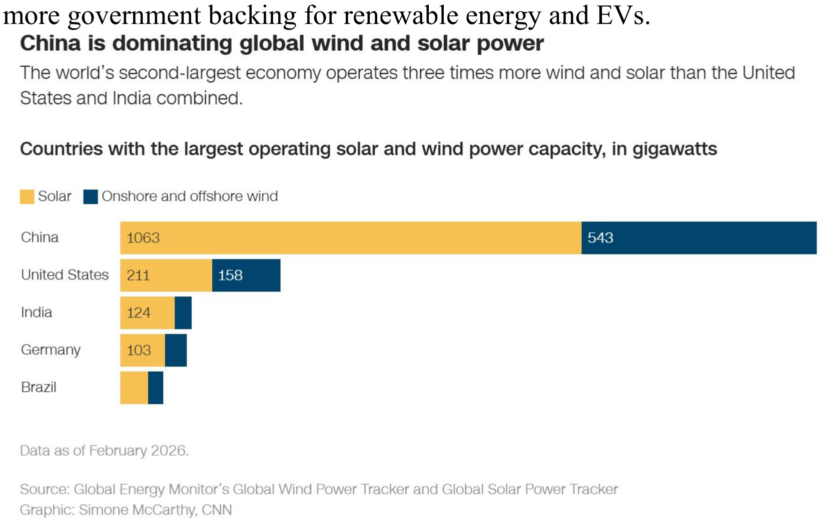
Its leaders have eyed the narrow waterways like the Strait of Malacca through which this fuel flows as potential chokepoints if a future adversary wanted to strangle Beijing's supply.

To reduce reliance on maritime routes, China has over recent decades built costly pipelines funnelling oil and gas over land from Central Asia, Russia and Myanmar. It's also diversified its sources, with Russia catapulting to the top of China's list of oil suppliers in the wake of Moscow's invasion of Ukraine.

But while his predecessors focused on expanding China's sources of oil and gas, Xi has also aimed to reduce China's reliance on the outside world altogether.

China must "adhere to worst-case-scenario thinking," Xi's adage goes, often repeated as he steels his cadres to prioritize national security in the face of what he sees as an increasingly hostile and volatile world.

Under Xi, Beijing ramped up a nascent push to both increase green energy and reduce reliance on fossil fuels, unleashing more government backing for renewable energy and EVs.



Now, sprawling solar and wind farms are being installed at breakneck pace across China's plateaued hinterlands and along its coastlines. Domestic factories have cracked the code on making cheap batteries for electric cars, which are fast replacing gas-guzzlers on China's highways. It helps that China dominates supply chains for materials needed to make these goods.

And the picture is diverse. In a country already running a third of global hydropower capacity, ambitious dam projects are breaking ground in China's mountainous west, while the government has set its sights on pioneering next-generation technologies like nuclear fusion and green hydrogen.

Meanwhile, rich coal deposits stretched across northern Chinese provinces continue to feed power plants and backstop renewable supply, in a reminder that China, the world's largest carbon emitter, has yet to kick its fossil fuel habit.And even as China is running much of its industry on electricity from renewables and coal, its state-owned energy giants have been probing deeper into the country's deserts and beneath its seabeds in search of more oil and gas – while building up crude reserves estimated to last at least several months.

In all, the world's second-largest economy imports what Chinese analysts suggest is only about 15% of its energy. But it still relies on imports for 70% of its oil and about 40% of its natural gas – and China hasn't been untouched by the economic turmoil unleashed by war in the Gulf.

Surging jet fuel prices have spilled over into higher ticket fees and even flight cancellations, transport costs are up, and elevated global commodities prices are buoying prices at the factory gate.

Central planners have intervened to cushion gas and diesel price hikes. Beijing has now given state refiners the green light to tap commercial oil reserves, according to a Bloomberg News report on April 10, citing people familiar with the matter.

And critically, Beijing's drive for self-reliance only goes so far for an economy whose vast manufacturing sector relies on healthy overseas demand as it faces weak consumption at home.

But as China has remained comparatively insulated amid the historic disruption of global oil markets – even clocking robust growth in the first quarter of 2026 – Xi and his planners appear even more assured in their strategy.

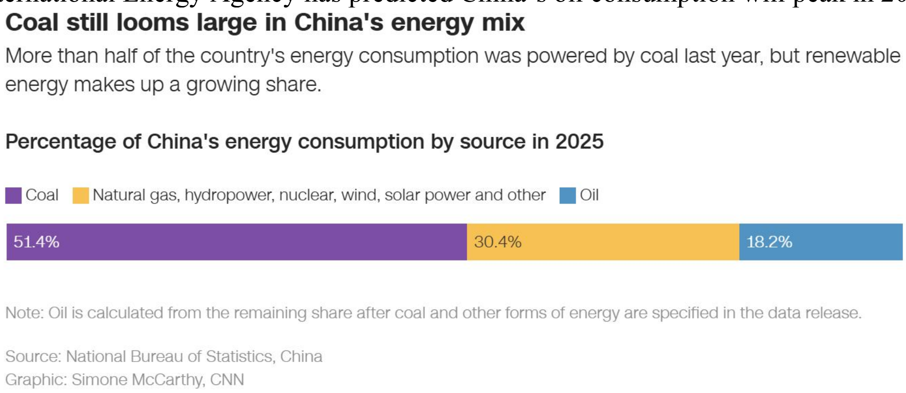
"We were early in developing wind and (solar) power, and that path now proves to have been forward-looking," Xi said late last month, according to a report from Chinese state broadcaster CCTV.

Oil wean

Today, China is far and away the leader in producing renewable energy – operating three times the wind and solar of the United States and India, the next two largest countries, combined, according to the Global Energy Monitor research firm.

The renewable share of China's energy mix is expanding at a rapid clip, with the aim to one day eclipse coal, even as China continues to lean heavily on the polluting fossil fuel to electrify its economy. (Critics say Beijing should set more ambitious targets to cut coal and meet its international climate pledges.)

The rise of electric and hybrid vehicles – which account for more than half of new vehicles sold in China – has reduced oil demand by more than 1 million barrels per day, according to a 2025 study by the Rhodium Group. The International Energy Agency has predicted China's oil consumption will peak in 2027.



"Before we worried about China's energy security, but now we know our solution is workable," said Lin Boqiang, dean of the China Institute for Energy Policy Studies at Xiamen University. "We have renewables, we have electric vehicles, and when oil prices get higher these vehicles become ever more competitive … but without 20 years of investment we wouldn't have this now."

Even still, Xi has not forsaken fossil fuels, still required for some industry and transport. In 2018, as trade tensions rose with the first administration of US President Donald Trump, he called for China's energy giants to revamp their own oil and gas production.

China reached record-high oil production last year, as companies pumped more from aging oil fields, put new technology to use on sprawling offshore reserves in China's Bohai Sea, and continued to drill boreholes miles deep into oilfields in far western Xinjiang in search of more supplies.

Critical to the energy security picture too, the government and its oil firms have kept their reserves flush, ramping up exports prior to the conflict to amass what trade data firm Kpler estimates to be some 1.3 billion barrels, or enough to cover three months, as of March.

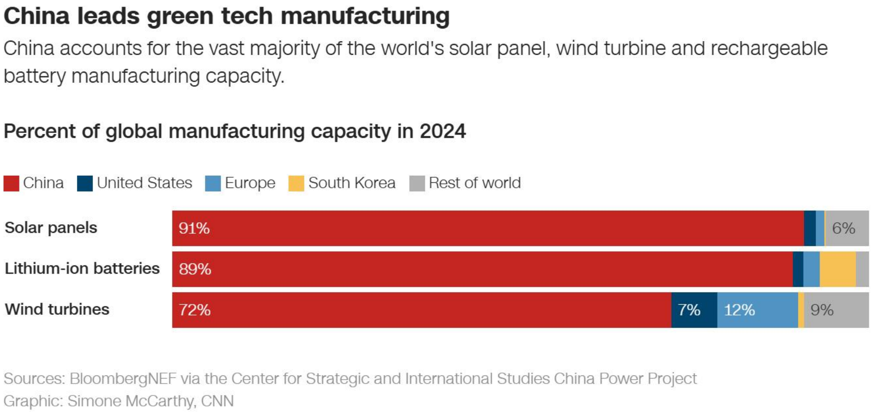
"The decision to emphasize the energy security and boost the stock reserve … is well paid back," said Muyu Xu, a Kpler senior crude oil analyst, referring to how China is weathering the current oil shock. "When it comes to products like gasoline and diesel, the supply should be assured, because that's the bottom line for China."

Green tech future?

Despite Beijing's "worst-case-scenario" planning, when Iran blocked traffic across the Strait of Hormuz in early March, China's exposure was large.

Some 38% of oil and 23% of liquified natural gas typically passing through the strait are bound for Chinese ports, according to financial firm Nomura. Overall, that accounts for about half of China's supply of imported oil and a sixth of its natural gas.

But that dependence makes China's resilience starker – and spotlights the contrast between Beijing's plan to electrify its economy and the model in the US, which some critics have dubbed a "petrostate" due to its reliance on fossil fuels.



Beijing is sure to see an opportunity for this contrast to play into Xi's broader message that today's world is "rife with chaos" but China (read: unlike the US) is a responsible and visionary leader for this age.

Already there are signs that the world is paying attention.

In the first quarter of this year, China's exports of green technologies surged, with electric vehicles, lithium batteries, wind turbine goods up 78%, 50%, and 45% year on year, according to official data.

The crisis could also open up more opportunity for that sector, which faces restrictions on certain green tech exports to countries including the US, Canada, and those in the European Union.

The closure of the Strait of Hormuz "will force every country to rethink their energy security, and move toward producing more energy domestically," said Xiamen University's Lin.

And when it comes to whether they want to use the batteries and wind and solar technologies that China is already producing at scale to do so, countries that previously were reluctant "may also need to think twice."

Southeast Asia's Resilience Tested by Deepening Energy Shock ⋆

By YASUTO WATANABE *

Asean+3 must prioritise flexibility and regional co-operation

The conflict in the Middle East has become more than a geopolitical flashpoint. For Asean+3 – comprising member countries of the Association of Southeast Asian Nations plus China, Japan and Korea – it is now a direct economic shock. With the region importing more than a third of its oil and gas from the Middle East, higher energy prices and financial volatility are feeding quickly into growth, inflation and market sentiment. The scale of the impact will depend on how long the conflict persists, but it can no longer be treated as a distant risk.

Entering from a position of strength

Asean+3 is, however, better prepared than in past episodes of stress. The region's experience is instructive: successive crises have strengthened policy frameworks, enhanced institutional credibility and deepened resilience. From the Asian financial crisis in 1997 to the 2008 financial crisis, and now amid trade fragmentation and technological disruption, policy-makers have adapted by becoming more pragmatic, disciplined and coordinated.

The latest regional outlook reinforces this point. Asean+3 entered 2026 from a position of relative strength, with growth of 4.3% in 2025 and inflation at 0.9%, giving central banks some room to absorb a supply shock without immediately tightening policy. It also allows fiscal authorities to support activity while maintaining a focus on medium-term sustainability. Even so, the Middle East conflict and disruptions to global energy supply have materially increased downside risks, with regional growth projected at 4.0% in both 2026 and 2027.

Resilience built through crisis

This resilience has not emerged by accident. It is the result of deliberate policy evolution over time. After the Asian financial crisis, the region strengthened macroeconomic frameworks, improved exchange rate management and placed greater emphasis on fiscal discipline. Macroeconomic credibility became a central policy objective – and remains one of the region's key strengths.

A second layer of reform followed the 2008 financial crisis. Although Asean+3 was not at the epicentre, the episode highlighted the region's exposure to global financial cycles. Policy-makers responded by strengthening macroprudential frameworks, improving supervision and building more robust banking systems. Today, banks are generally well capitalised and liquid, though vulnerabilities in property markets, corporate leverage and household debt still warrant close attention.

A third phase of adjustment is now under way. It is being driven by geopolitical fragmentation, trade tensions and rapid technological change. The current Middle East conflict has intensified these pressures, while supply chain realignment and tariff uncertainty are forcing economies to rethink growth models. For Asean+3, a region deeply embedded in global production networks, the challenge is to remain open, competitive and resilient at the same time.

Policy flexibility and co-operation

Flexibility has therefore become the region's most valuable policy asset. Singapore continues to draw on its institutional credibility as a global financial and logistics hub. Malaysia is pushing industrial upgrading and investment facilitation. Vietnam remains central to manufacturing supply chains. Across the region, governments are investing in digitalisation, advanced manufacturing, human capital and infrastructure. The goal is not narrow sectorial targeting, but broader adaptability.

⋆ The article was first published on OMFIF on April 21st, 2026

* Yasuto Watanabe, Director and CEO of ASEAN+3 Macroeconomic Research Office. He is former Senior Deputy Vice Minister at Japan Ministry of Finance.

The policy implications are clear. In the current environment, rigid policy templates are less effective than pragmatic management. Monetary policy must distinguish between temporary supply shocks and broader inflationary pressures. Fiscal policy must remain flexible and responsive while rebuilding space without undermining growth. Financial supervision must remain vigilant even when headline indicators appear stable. Resilience is not a fixed condition; it is a continuous process of adjustment.

Regional co-operation is increasingly central to that process. Initiatives such as cross-border digital payments, financial infrastructure integration and deeper policy dialogue are helping the region absorb shocks more effectively. In a more uncertain world, such co-operation is not optional. It is a core pillar of stability.

The broader lesson is that shocks can be catalysts. They expose vulnerabilities but also drive reform. Asean+3 has moved from fragility towards a more robust and pragmatic model of policy management. That progress should not invite complacency. It should reinforce the need for vigilance, flexibility and co-operation.

As the Asean+3 Macroeconomic Research Office marks its 10th anniversary, its role in identifying risks early, supporting sound policy and strengthening regional co-operation becomes even more important. The region is entering a more turbulent phase, but it is better equipped than in the past to navigate it. The priority now is to preserve credibility, remain adaptable and keep co-operation at the centre of the response.

IMI International Monetary Review

Navigating Energy Shocks—Risks and Policy Responses ☆

By CHRISTINE LAGARDE *

It is a pleasure to be back at the ECB Watchers Conference.

If this event had been held a few weeks ago, my speech would have been very different. The euro area economy ended the year with solid growth momentum. Inflation stood at 1.9% in February. And domestic growth engines looked to be strengthening, particularly private consumption, investment in digitalisation and defence spending.

In all likelihood, we would have revised up our March forecasts for growth and revised them down for inflation.

But we find ourselves yet again in a different world, whose contours are not yet clear. We are facing profound uncertainty about the path of the economy.

None of us can resolve the uncertainty about how the war in Iran will play out. But what I can do is set out how we will approach this shock.

The main message I want to convey is that our response will be rooted in our monetary policy strategy, which is well equipped to help us navigate it.

Our strategy sets out three principles that will guide us.

First, it requires us to assess the nature, size and persistence of the shock before taking decisions on policy.

Monetary policy cannot bring down energy prices. But we must identify when higher energy costs risk spilling over into broad-based inflation – be it through indirect effects or through second-round effects via wages and inflation expectations.

Second, it requires us to focus on risks, not only the baseline.

Because the effects of significant price shocks on inflation can be non-linear, we need to work with scenarios and pay close attention to early warning signs that the shock is embedding in broader inflation dynamics.

Third, it gives us a graduated set of options for how to respond, which depend on the intensity and duration of the shock and how it propagates.

Small, one-off and short-lived supply shocks can be looked through. But as expected deviations from our inflation target grow larger and more persistent, the case for action becomes stronger.

Assessing the shock

Central banks have a long history of dealing with inflationary energy shocks, and over that time we have built up a substantial body of evidence about when they risk spilling over into generalised inflation.

In the euro area, the historical evidence suggests that the risk of broad pass-through from energy prices is the exception rather than the rule. When shocks are small in magnitude and short in duration – as has most often been the case – their inflationary impact tends to largely stay within the energy component itself.

But two factors can change that picture.

The first is the intensity and duration of the shock.

ECB research shows that the relationship between energy price shocks and inflation can be non-linear: while small increases trigger no significant reaction in prices, larger shocks have disproportionately stronger effects.

The second is the propagation of the shock, which depends on the macroeconomic environment in which it lands.

Firms are more likely to be able to raise prices when demand is stronger, workers are more likely to be able to bargain for higher wages when labour markets are tighter, and both are more likely when inflation is already high.

ECB research confirms that pass-through is measurably stronger when capacity utilisation is high and unemployment is low – and that wages feed into prices more forcefully when inflation is already elevated.

How people have experienced inflation in the recent past also matters. Research shows that lived experiences of inflation can have lasting effects on how people form expectations, with recent salient episodes carrying disproportionate weight.

☆ Keynote speech by Ms Christine Lagarde, President of the European Central Bank, at "The ECB and Its Watchers" conference, organised by the Institute for Monetary and Financial Stability at Goethe University Frankfurt, Frankfurt am Main, 25 March 2026.

* Christine Lagarde, President of the European Central Bank.

When the energy shock hit in 2021–22, several of these channels were operating simultaneously. But there are factors today which point to a lesser pass through.

First, the initial shock has so far still been smaller.

In 2022, the shock was exceptionally large and persistent. Even before the Russian invasion began, oil prices had increased threefold between October 2020 and March 2022 – and natural gas prices by even more as Russia gradually throttled supplies.

Thereafter, Europe was effectively cut off from a supplier that had provided around 45% of its natural gas imports and forced to find new suppliers, compete in the global LNG market and build new import infrastructure.

Oil prices peaked at around $130 per barrel in March 2022, a comparable level to today. But gas prices surged to much higher levels than we have seen so far: €340 per megawatt hour in August 2022 versus around €60 today.

Second, the macroeconomic backdrop today is more benign.

In 2022, the economy was primed for pass-through. Europe was experiencing strong pent-up demand after the post-pandemic reopening. Supply chains were still disrupted after the pandemic. There were significant labour shortages. Headline inflation at the onset of the shock stood at more than 5%.

ECB analysis confirms that this combination of factors exacerbated the inflationary effects. In particular, in the absence of demand pressures, the impact of supply-side shocks on inflation would have been considerably lower.

Today, the euro area economy is in a moderate recovery, without the pronounced demand-supply imbalances that characterised 2022. Headline inflation has been close to our target for almost a year. The unemployment rate is low by historical standards but we no longer face acute labour shortages.

Third, macroeconomic policies are less supportive.

When the invasion began in 2022, monetary policy was highly accommodative, with interest rates at -0.5% and the ECB still engaged in net asset purchases. The fiscal stance was also expansionary, with an aggregate deficit of over 5%.

Interest rates today are broadly at their neutral level and the fiscal stance is neutral, too, with an aggregate fiscal deficit of around 3%.

At the same time, there are reasons for vigilance.

The International Energy Agency has described this as the largest supply disruption in the history of the global oil market, and with the attacks on energy infrastructure – especially the Ras Laffan facility in Qatar last week – the likelihood of a quick normalisation is diminishing.

A further cliff edge is also approaching: global oil reserves are being drawn down, and the last LNG tankers that loaded in the Gulf before the war are now reaching their destinations, meaning the full impact of lost supply is only about to be felt.

And if the shock does intensify, the response of firms and workers may be faster than last time. We have a more recent memory of high inflation, which could affect how quickly costs are passed on and compensation is sought.

During the inflation surge, firms shifted to adjusting prices significantly more frequently: the share of consumer prices changing in any given month rose from around 8% to 12%. As inflation came down, that frequency returned to near-normal levels. But the operational experience of rapid repricing remains.

On the worker side, the initial response was relatively slow: after a long period of price stability, it took time for employees to seek inflation compensation. But research shows that as inflation rose, people began paying more attention to price developments, particularly when inflation was far from target.

Even though the 2022 shock was brought under control, that experience has left a mark. An entire generation has now lived through its first episode of high inflation – and it may not be as slow to react a second time.

Managing uncertainty

So we face a situation where, if the current shock remains contained in energy markets, it may have a limited effect on broader inflation. But if it intensifies or persists, the pass-through could accelerate.

How can we calibrate policy under this uncertainty?

There are two key elements.

The first is agility. We have followed for some time now a meeting-by-meeting, data-dependent approach without pre-committing to a particular rate path. This was precisely because we did not want to have our hands tied in an environment where the outlook could change rapidly.

In 2022 we were still bound by forward guidance on asset purchases and rates when the energy shock hit. That pre-commitment limited our flexibility to act. Now, we are prepared, if appropriate, to make changes to our policy at any meeting.

The second element is a focus on risks.

Last year, we updated our monetary policy strategy with precisely the type of challenge we face today in mind. We judged that we were moving into a world of more frequent supply shocks – we have faced at least four major ones since 2020 – and structurally higher uncertainty.

We decided that, in this environment, we needed to take into account not only the most likely path for inflation, but also the risks and uncertainty surrounding the baseline. This emphasis on risks was embedded in our reaction function in July 2025.

Given the range of possible outcomes we face today, scenarios are an especially valuable way to capture risks. They allow us to explore what could happen if key variables were to change – in particular, if the intensity, duration and propagation of the shock differ from our baseline assumptions.

ECB staff published two such scenarios last week. These are not forecasts: they are illustrations, constructed among other things under a no-policy-change assumption. And we will review and update our scenario analysis regularly.

The adverse scenario assumes that the shock intensifies but its duration is relatively short, containing its propagation through the economy.

Relative to the baseline, annual inflation moves almost one percentage point higher this year but falls back steeply by 2028, as indirect and second-round effects are outweighed by a large energy-related base effect. Growth would be somewhat lower in 2026 and 2027, before recovering in 2028.

The severe scenario assumes greater intensity, longer duration and broader, more persistent propagation.

Relative to the baseline, annual inflation would be significantly higher across the horizon – by almost three percentage points in 2027 – and would not return to target within the projection period.

Growth would be notably weaker in 2026 and 2027, by almost one percentage point cumulatively, before rebounding in 2028.

These scenarios highlight a crucial feature of the current environment: the non-linearity of the risks to inflation. As the shock grows in size and persistence, the response of prices and wages accelerates. The deviation from target widens disproportionately unless monetary policy steps in.

Because of these non-linearities, it is essential to identify as early as possible when the shock is at risk of broadening. That means tracking closely the indicators that can signal ahead of time the size and timing of indirect and second-round effects.

This will depend, naturally, on developments in commodity markets, because a sufficiently large shock will always spread beyond the energy component.

But it will also depend on how the burden of the shock is shared. As a net energy importer, a spike in energy prices creates a terms-of-trade tax for the euro area, which must be absorbed by some combination of workers, firms and governments.

If firms increase their selling prices disproportionately – as we saw in 2022 – it could trigger an equivalent response from workers, what I have called in the past tit-for-tat inflation. We will therefore watch carefully firms' selling price expectations and micro evidence on price changes, as well as paying close attention to wage trackers.

We will also monitor the demand side, as the risks to growth are on the downside. A negative supply shock weighs on demand, which can reduce the ability of firms to pass on costs and of workers to bargain for higher wages.

So far, consumer confidence has fallen more sharply in Europe than following the 9/11 attacks and the war in Kuwait in 1990, but not as steeply as following the Russian invasion of Ukraine. If households increase precautionary saving as they budget for higher energy bills, it could point to a more limited pass-through.

The fiscal response will matter. Targeted government policies can help smooth the shock by reducing energy demand and compensating lower-income households. But broad-based and open-ended measures may add excessively to demand and strengthen the pass-through.

On the appropriate policy response to supply shocks

Our strategy also helps us define how to set monetary policy appropriately.

Supply shocks are often presented as offering central banks a binary choice: either look through, or react when inflation expectations are at risk of being de-anchored. But in reality we can respond in a more graduated way.

In line with the medium-term orientation of our strategy, the appropriate response to a deviation of inflation from the target is context-specific and does not depend only on its origin – here, a supply shock – but also on its magnitude and persistence.

This points to three broad cases.

First, if the energy shock is seen to be limited in size and short-lived, the classical prescription of looking through should apply. Transmission lags mean that a monetary policy response would arrive too late and risk being counterproductive.

Second, if the shock gives rise to a large though not-too-persistent overshoot of our target, some measured adjustment of policy could be warranted. The optimal response to such a deviation is smaller when the cause is exogenous supply disruptions rather than strong demand, but it is not necessarily zero.

Moreover, to leave such an overshoot entirely unaddressed could pose a communication risk: the public may find it difficult to understand a reaction function that does not react.

Third, if we expect inflation to deviate significantly and persistently from target, the response must be appropriately forceful or persistent. Otherwise, self-reinforcing mechanisms would kick in and the risk of de-anchoring would become acute.

Our updated strategy is explicit on this point: large, sustained deviations call for forceful monetary policy action, shifting to persistence as the tightening cycle matures, to prevent those deviations from becoming entrenched.

It is too early to say where on this spectrum we will need to be. Fortunately, we can assess the situation carefully, because we are entering this shock from a good starting point. The policy stance is broadly neutral, inflation has been on target for around a year and longer-term inflation expectations are well-anchored.

In the period ahead, incoming information will give us greater clarity on how the conflict is likely to evolve and how the economy is responding. We will monitor developments closely and set monetary policy as appropriate to deliver on our target.

Conclusion

Let me conclude.

Four years ago at this conference, as the energy shock from Russia's invasion of Ukraine was unfolding, I borrowed a line from Bertrand Russell: that the challenge we face is learning "how to live without certainty, and yet without being paralysed by hesitation."

Those words capture our challenge today just as precisely. But we are not in the same position as we were four years ago.

We have a strategy that is built for a world of higher uncertainty, with risks and scenarios at its core. We have a graduated set of options for responding. And we are starting from a better place should we need to act.

We will not act before we have sufficient information on the size and persistence of the shock and its propagation. But we will not be paralysed by hesitation: our commitment to delivering 2% inflation over the medium term is unconditional.

Toward a European Energy Union *

By KRISTALINA GEORGIEVA *

Thank you, Kyriákos, for your invitation to address ministers today on energy security.

Three months into the Middle East war, global oil supply remains down by some 13 percent relative to pre-war levels, and global LNG supply by some 20 percent.

The impact of this war is very asymmetric, depending on whether countries are taking direct hits, who is a net importer or exporter of oil and gas, and who has policy space.

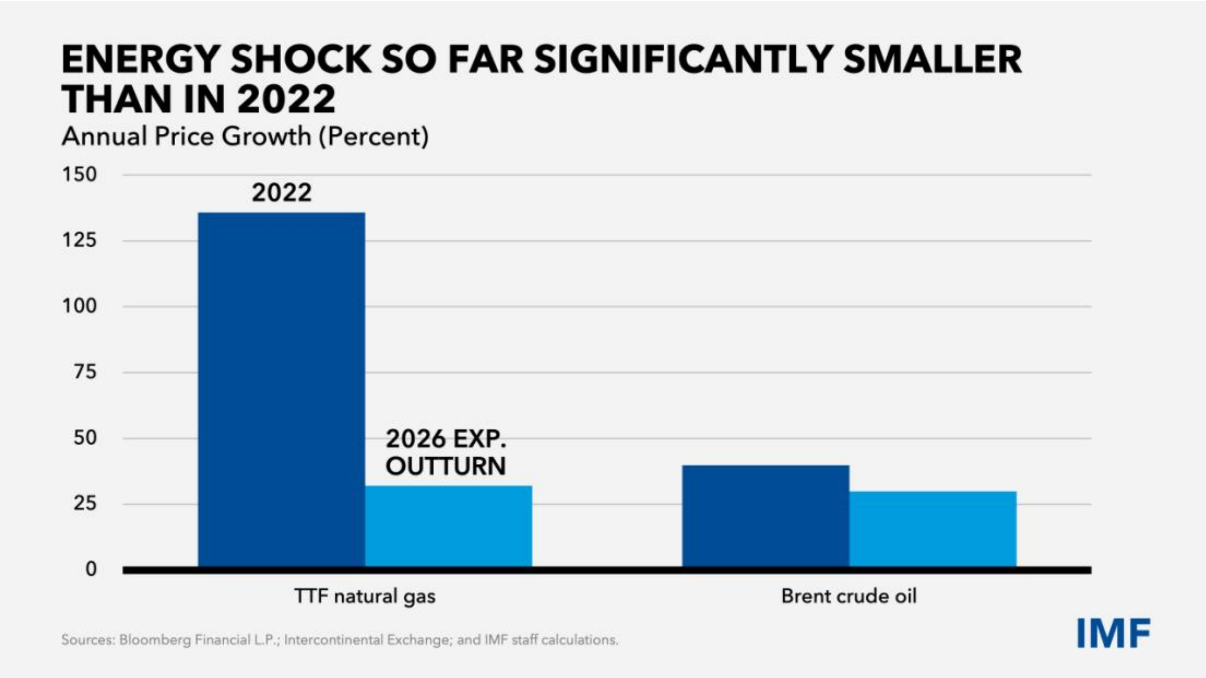
Low-income countries and emerging markets reliant on imports are hit especially hard by the higher fuel and fertilizer prices.

So let me start with an appeal. Europe: standing in solidarity with the broader international community, please step up to support the hardest hit and least fortunate countries, wherever they may be, including by facilitating their access to fertilizers and critical refined products such as diesel.

And as for this continent, I want to start with a big thumbs-up: congratulations to Europe for the visionary policies you have pursued over the years—your steadfast emphasis on the energy transition.

These policies have cut the energy intensity of EU output by more than 40 percent over 30 years while also cutting oil dependence. They leave Europe far less exposed than might otherwise have been the case.

Those of you who are veterans of 2022 know that today's gas price shock is much smaller than what Europe saw last time around. But for oil, the shock is almost as large. So far, the main effects are in transport costs. Over time, however, reserves could deplete and, yes, winter will come, adding heating costs to the mix.

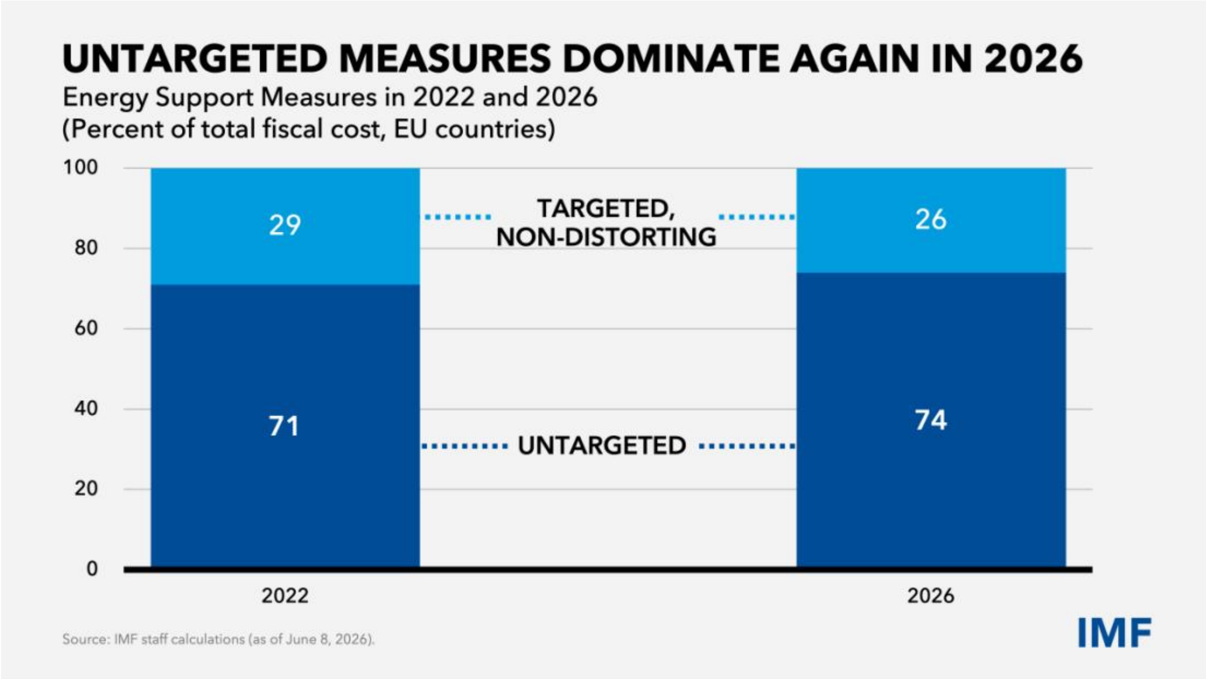


Some things don't change, of course, and political economy is one of them: governments once more feel the pressure to provide broad-based fiscal support.

Most of your new measures are temporary—bravo—even if sunset clauses may not be watertight. And well done also for keeping the fiscal costs much lower than in 2022—very important!

That said, I regret that most of the new measures are again untargeted, muting the price signal. The result? Less energy savings—with global spillovers and damaging impacts for poorer nations—as well as reduced fiscal efficiency.

* Speech by Kristalina Georgieva, at the Eurogroup in Inclusive Format, June 11, 2026.
* Kristalina Georgieva, IMF Managing Director.



In response to the 2022 shock, over two-thirds of EU support was poorly targeted or price-suppressing. A better-targeted plan—fully protecting the poorest 40 percent of households but stopping there—would have saved almost two-thirds of the fiscal cost. Instead, the wealthiest quintile received nearly three times more than the poorest.

Let us learn the lessons: this is why we at the IMF urge that any further support be targeted. Our advice? Use the temporary state aid provisions in ways that ensure needed energy savings still happen.

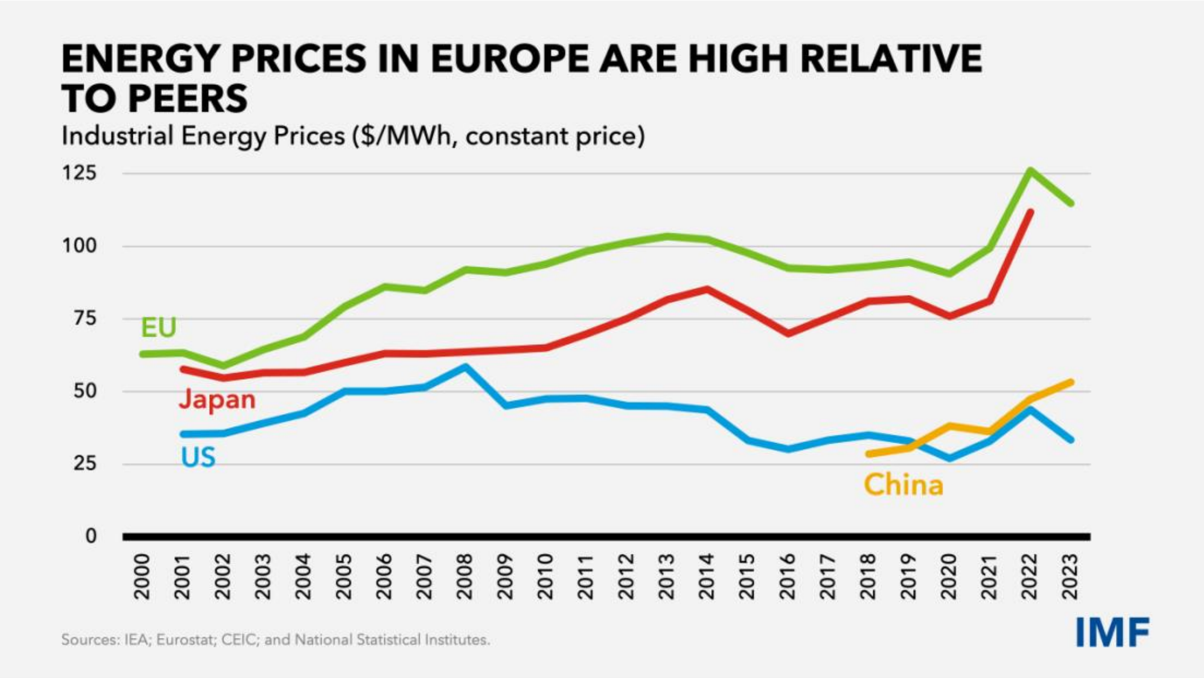
And as you help households and firms adjust in the short run, please stay laser-focused on the long-term goal of energy security. Yes, Europe has done much over the years. But more is needed.

Three more positives. One, policy actions taken after 2021 have canceled Europe's energy dependence on Russia—a very big deal. Two, without the energy efficiency gains over the same period, we estimate the lasting damage to euro area GDP from the Ukraine shock would have been two-thirds larger. And three, despite some distortions, today we see tentative but positive signs of higher investment in energy efficiency.

Well done indeed. But still, let's step back and recognize that the bitter experience of two massive energy shocks in four years is a call to urgent, high-priority action.

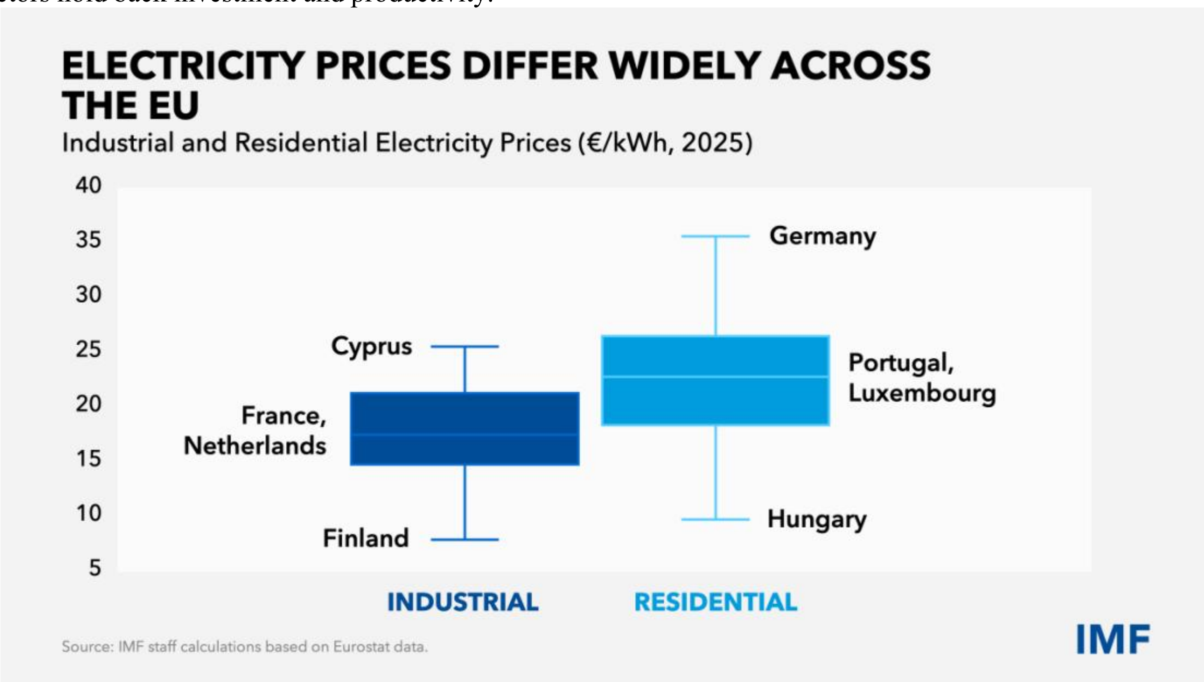
So here is my call: getting to energy union stands to address two interlinked problems—competitiveness and economic security. Let me offer three facts.

Fact one: energy prices in Europe are high by international comparison. This is especially true for electricity, where European industrial users have over the past few years been paying 2–3 times more than their competitors in the U.S. and China. This hurts competitiveness.

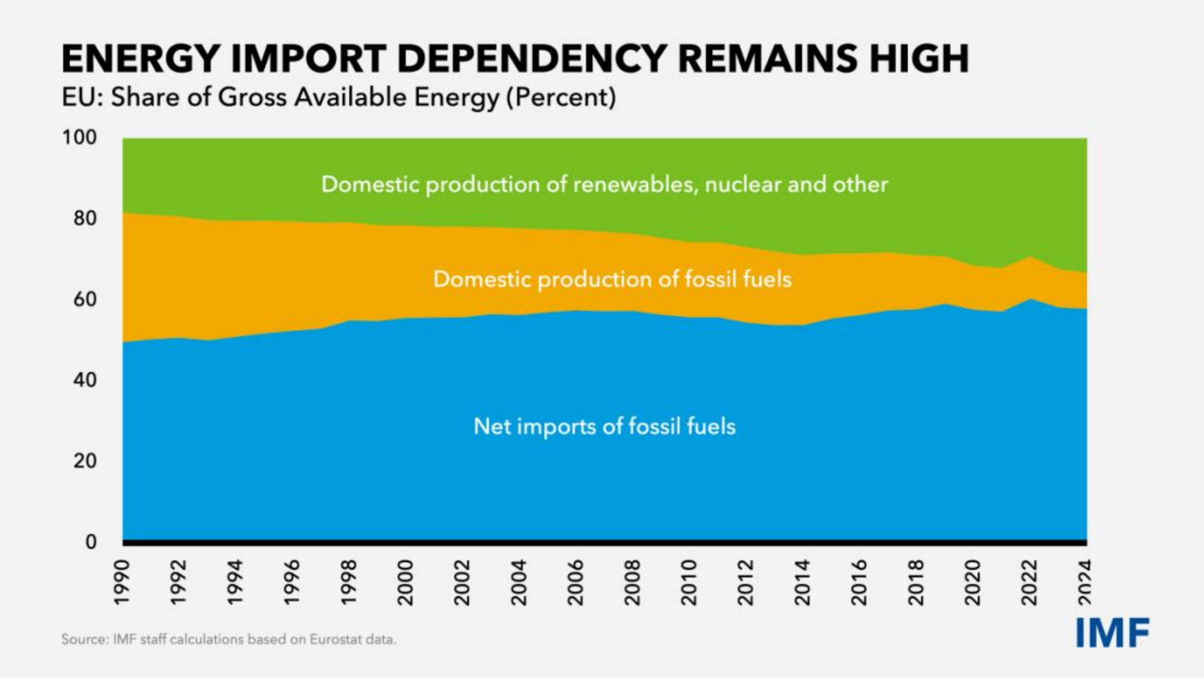


Upcoming IMF research will show that, over the past two decades, the doubling in real terms of EU industrial energy prices has reduced value added in energy-intensive industries by an estimated 18 percent. Lest we forget: energy-intensive industries include game-changing AI.

Fact two: Europe's problem is not only high average energy prices, but volatility and dispersion. Energy price volatility has increased sharply since 2021. And industrial electricity prices in some EU countries are more than three times higher than in others—a startling outcome for a supposedly single market. Both factors hold back investment and productivity.



Fact three: vulnerabilities related to fossil fuel imports remain high. Despite all the progress on renewables, the EU continues to import more than 50 percent of its energy needs, a ratio broadly unchanged since 1990 given the trend decline in domestic fossil fuel supply. External supply disruptions still swiftly ripple through to domestic prices and activity, undermining economic security.

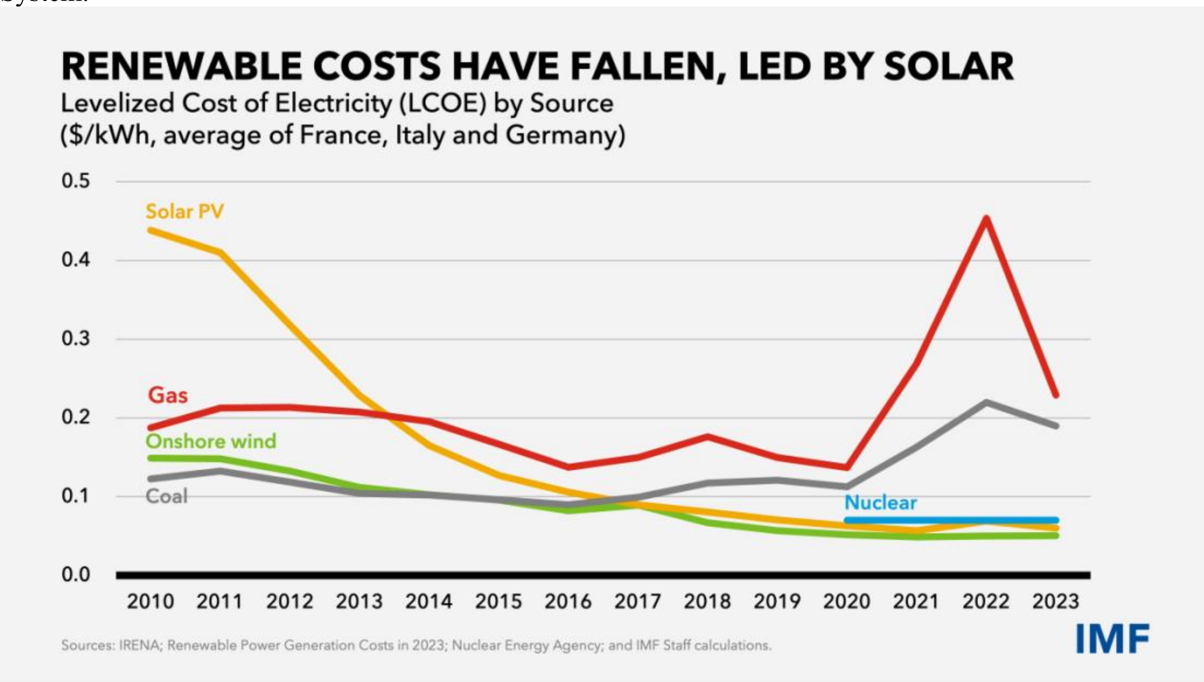


It is late in the day, but I do hope that by now some of you may be asking: how best to address these connected challenges?

My answer: turbocharge your drive to the energy transition targets you have already set. Accelerate the rollout of renewable energy—which keeps getting cheaper. And pursue two more priorities:

One, better integrate the EU's internal energy market; and

Two, preserve the right incentives for the private sector, including through the Emissions Trading System.

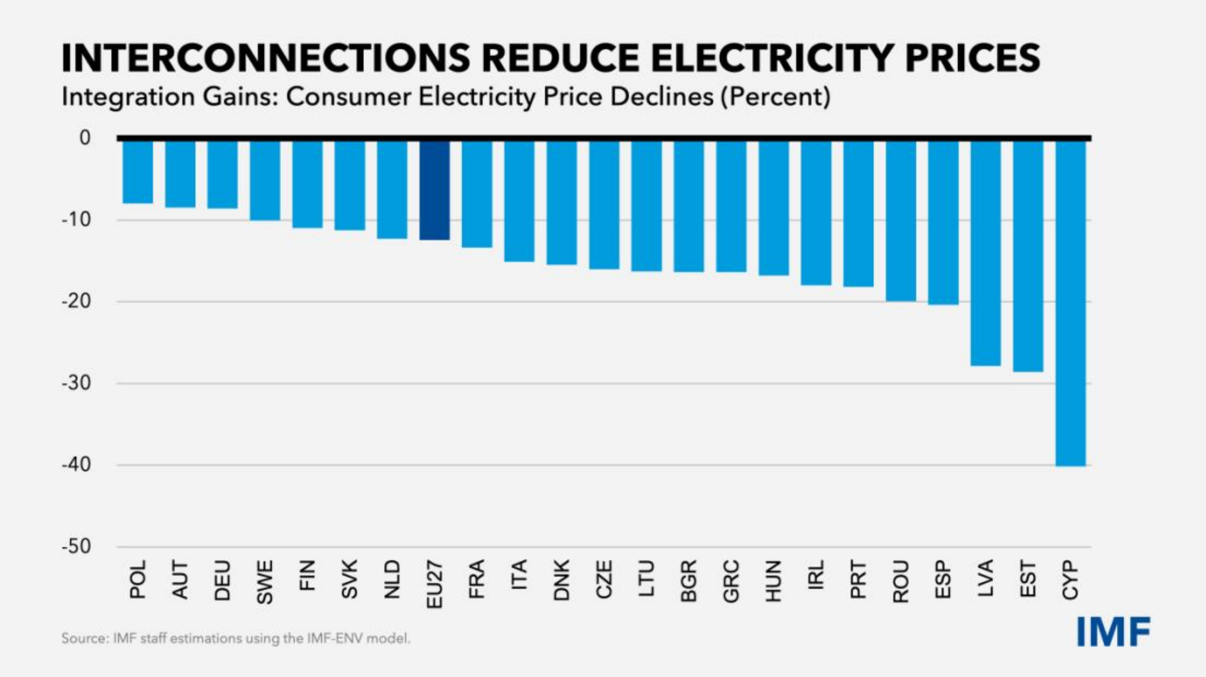


Integrating Europe's energy market requires faster expansion of electricity grids and interconnectors, with due deference to technical transmission losses. When electricity cannot flow across borders, local shortages cause local price spikes while cheaper electricity elsewhere goes to waste.

Some worry that with cross-border trade electricity-exporting countries could see higher domestic prices, triggering political backlash. This, in our view, can be addressed by redistributing part of the export revenue back to the public.

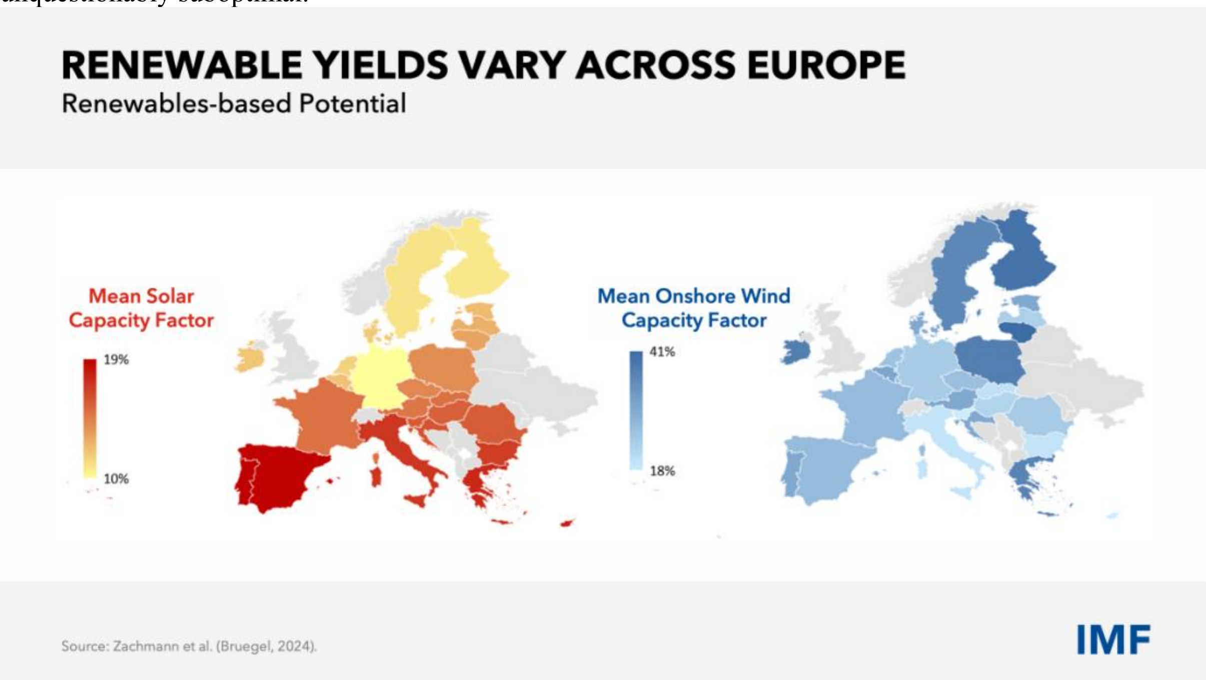
Moreover, forthcoming IMF research will show that in many cases prices have fallen in both the energy-surplus and energy-deficit country after an interconnector is built, because deeper markets allow a more efficient matching of supply and demand over time and location.

Our analysis suggests completing the interconnectors already planned—paired with further expansion of solar, wind, and nuclear—can lower average EU electricity prices by more than 10 percent. The gains are largest where interconnectors relax binding capacity constraints.



We see welcome steps—for instance, the European Commission's Grids Package; the plan to increase EU funding for the Connecting Europe Facility; and recent efforts to streamline permitting at the EU, national, and local levels. We hope for swift political agreement on all these fronts.

But further progress calls for a more comprehensive approach. A common EU energy blueprint—covering low-cost supply, storage, and interconnections—would help unlock the full benefits of the energy transition. This matters in part because renewables are unevenly spread across Europe—wind in the North, sun in the South—such that purely national approaches to generation, storage, and grids are unquestionably suboptimal.



And let's not forget that energy union is a key support for a better single market, where there are enormous gains to be had: a 35 percent uplift to per capita income, or more, if Europe can deliver deep reforms at the EU and national levels.

As I flagged early on, let me also stress that private sector incentives delivered through price signals need to be well aligned with the objectives. For this reason, we prefer the Emissions Trading System be protected as a mechanism to spur long-term investment in clean energy—even if it elevates costs in the near term.

In a recent IMF paper we calculated that government revenues from the ETS could eventually amount to about 1 percent of GDP, exceeding the public investment cost of the transition, leaving net fiscal space for other purposes.

More broadly, we find that the EU's energy transition has few adverse effects on growth, inflation, and the public finances if it employs a suitable blend of carbon pricing and targeted subsidies.

With that key finding, let me conclude, quite simply, by urging you to use the moment. There is that saying, "Never let a crisis go to waste." I trust that Europe will take heed and act—decisively and as one.

Work with energy ministers, work with Brussels, make energy union a reality.

Thank you.

IMI International Monetary Review

UAE's OPEC Exit Is a Bet on Post-Hormuz Energy Power ⋆

By YARA AZIZ *

Sovereignty, capital and national flexibility are taking precedence over cartel discipline

For decades, being part of the Organization of the Petroleum Exporting Countries was a source of leverage for members. It gave producers collective influence over prices and a forum through which to coordinate supply. But for the United Arab Emirates, the calculation has changed. Collective restraint now has to be weighed against the cost of constrained output, delayed monetisation and reduced room for manoeuvre in a less predictable energy transition.

The UAE has spent years building an economic model that is less dependent on crude exports and more centred on logistics, tourism, finance, technology, real estate and global capital flows. Abu Dhabi and Dubai have positioned themselves as hubs for trade, investment and geopolitical intermediation. That does not make oil less important, but it does make oil revenues more strategically useful. Hydrocarbon income is no longer just fiscal support. It is capital to be deployed into the next stage of national development.

That shifts the logic of production restraint. For less diversified producers, supporting prices through OPEC discipline may be essential to fiscal stability. For the UAE, which has stronger buffers and a broader economic base than many other producers, the case for volume, market share and investment flexibility is stronger. The aim is not to abandon oil but to control the timing and terms under which oil wealth is converted into sovereign wealth.

A wider tension in the region

This is where the exit becomes more significant than a bilateral disagreement with Saudi Arabia or a technical dispute over baselines. It points to a wider tension inside the Gulf. The region's producers are not at the same stage of economic transformation. They do not face the same fiscal needs, demographic pressures or energy transition risks. A single production framework can therefore sit awkwardly with national strategies. The UAE's message is not that OPEC has no value, but that its value is no longer absolute.

The timing matters because the UAE is not leaving OPEC in a normal oil market, but during a regional crisis in which traffic through the Strait of Hormuz has been severely disrupted by the US-Iran war. That makes the decision less about immediate production gains and more about control. If Gulf export routes can no longer be treated as secure, then control over production, investment and monetisation becomes even more valuable.

For global markets, the immediate price effect will depend less on the UAE's formal exit than on the duration of the Hormuz disruption, the security of Gulf shipping and the pace at which Abu Dhabi can bring additional barrels to market once routes reopen. But the structural implication is clearer. If one of OPEC's most capable and financially resilient members decides that unilateral flexibility is preferable to cartel discipline during the biggest Gulf energy shock in years, the group's long-term cohesion becomes harder to take for granted.

A question of political willingness

That matters because OPEC's influence has never rested on barrels alone. It has rested on the belief that its core members share enough common interest to manage supply when prices come under pressure. The UAE's departure weakens that perception and introduces a new question into oil-market pricing: not only how much capacity exists, but how much political willingness remains to coordinate it.

The consequences extend beyond energy traders. Central banks, finance ministries and sovereign investors have all benefited from a world in which OPEC, despite its flaws, acted as a stabilising force in oil markets. A weaker producer coalition could mean more volatility in inflation forecasts, external balances and fiscal planning. For oil importers, additional supply may be welcome. For exporters with weaker buffers, it may sharpen fiscal stress. For monetary policy-makers, a less predictable oil market makes it harder to distinguish temporary price shocks from persistent inflationary pressure.

Gulf oil revenues have long shaped global liquidity through sovereign funds, bank deposits, real estate investment and portfolio flows. If Gulf producers become more nationally driven in their production strategies, the recycling of oil surpluses may also become more differentiated. The UAE is likely to channel

⋆ The article was first published on OMFIF on May 7th, 2026.
* Yara Aziz is a Senior Economist at OMFIF.

energy revenues into sectors that reinforce its position as a global platform economy: artificial intelligence, infrastructure, ports, finance, clean energy and strategic overseas assets. In that sense, leaving OPEC may not reduce the UAE's global influence. It may make that influence more directly aligned with national priorities.

Energy transition paradox

The move also says something about the politics of the energy transition. Much of the climate debate assumes that producers face a simple choice between pumping less oil or resisting transition. The reality is more complicated. Some producers may choose to accelerate monetisation precisely because they see where the long-term market is heading. If future demand is uncertain, the rational strategy may be to maximise the value of reserves while they still carry high strategic and financial weight.

That creates a paradox for energy transition. The more credible the long-term transition becomes, the stronger the incentive for low-cost producers to defend market share today. For the UAE, with efficient production and large investment ambitions, the question is not whether oil demand eventually peaks. It is how much value can be captured before that peak reshapes producer economics.

This is why the UAE's exit should be seen as part of a broader shift away from cartel discipline and towards national control. In the past, producers were expected to limit national capacity in the service of collective price management. Now, they are increasingly prioritising balance sheets, investment cycles, geopolitical autonomy and the need to turn hydrocarbon advantage into post-oil resilience.

OPEC will not disappear because the UAE has left. Saudi Arabia remains central to the group, and many producers still need the price support that coordination provides. But the UAE's departure exposes a strategic divergence that will be hard to reverse. The Gulf's leading economies are becoming more ambitious, more competitive and more willing to pursue national advantage outside inherited multilateral structures. For markets, the question is whether this marks an isolated rupture or the beginning of a more transactional era in producer politics.

IMI International Monetary Review

When Supply Shocks Outlast Conflict [⋆]

By ANDREA CORREA [*]

Markets brace for prolonged economic shock sparked by energy disruptions

The trajectory of the current Middle Eastern conflict, as it pertains to the US, Israel and Iran, remains highly uncertain with no clear indication of de-escalation. Market participants are tentatively bracing for a several-week duration, but this short-term horizon does not alleviate the deeper concern that the economic consequences may persist well beyond the cessation of hostilities. This divergence between the expected timeline of the conflict and its resulting economic fallout is shaping investor behaviour in a number of ways.

The extent of disruption to critical supply routes, particularly through the Strait of Hormuz, will determine whether the shock is transitory or enduring. Markets are already pricing in scenarios in which energy flows remain constrained for months, due to prolonged closures, physical damage to infrastructure or escalation involving additional regional producers. In this sense, the conflict stands to become a potential catalyst for a sustained energy shock, with far-reaching implications for inflation, growth and financial stability.

Shifting expectations

Currency markets have been among the most immediate transmitters of this risky environment. The dollar has strengthened markedly, reaching levels not seen since the end of 2025. This reflects a renewed demand for dollar-denominated assets as investors seek safety amid heightened uncertainty. The move has been reinforced by relative weakness in other major currencies, particularly those of economies more exposed to rising energy costs. Both the euro and the yen have come under pressure, emphasising the asymmetric impact of the shock across advanced economies.

Importantly, the dollar's appreciation is not solely a function of risk aversion. It is also being supported by a recalibration of monetary policy expectations. As energy prices rise and inflation risks intensify, markets have tempered their expectations for interest rate cuts in the US. Higher-for-longer rate assumptions increase the relative attractiveness of dollar assets, further amplifying their safe-haven appeal.

In contrast, gold's performance has been more nuanced. After an extended rally earlier in the year, the metal has recently slipped below the $5,000 per ounce. This reflects the influence of higher expectations for borrowing costs, which tend to weigh on non-yielding assets. Yet despite this short-term weakness, gold remains significantly higher, suggesting that investors continue to view it as a hedge against broader macroeconomic risks, particularly those associated with stagflation.

Gold's role in the current context extends beyond the immediate dynamics of conflict. It serves as a form of insurance against the secondary effects of geopolitical shocks, such as currency depreciation, fiscal deterioration and slowing growth. Should the energy shock translate into a more persistent inflationary environment combined with weaker economic activity, the case for gold as a store of value may strengthen once again.

Regional impacts of the conflict

Nowhere are the real-economy implications of the conflict more evident than in emerging markets, particularly Asia. The region's heavy reliance on imported energy, much of which transits through vulnerable routes, makes it acutely sensitive to supply disruptions. For many Asian economies, this is not merely a question of higher prices but of physical availability. While price shocks can be mitigated through subsidies or monetary policy, supply shortages necessitate more immediate and often disruptive adjustments.

Governments across Asia have already begun to implement such measures. In countries like Vietnam, Thailand, the Philippines and Pakistan, policies have been aimed at curbing energy consumption and preventing panic buying. From adjustments to work arrangements and travel restrictions to the reallocation of fuel supplies and reductions in industrial usage, these interventions highlight the situation's severity as well as the structural vulnerabilities that underpin it. They also point to the broader economic costs of the shock, as efforts to conserve energy inevitably weigh on productivity and growth.

China presents a somewhat different picture. While the oil shock has exerted downward pressure on its currency, the impact has been relatively contained. This reflects a combination of active policy management and longer-term structural shifts in the energy mix. Investments in renewable energy, the expansion of

[⋆] The article was first published on OMFIF on March 31st, 2026.
[*] Andrea Correa is Head of Research at OMFIF.

electric vehicle adoption and efforts to enhance domestic energy security have all contributed to reducing the economy's sensitivity to external shocks. As a result, while not immune, China appears better positioned than many of its regional peers to absorb the immediate impact.

Beyond Asia, the effects across emerging markets rely on the distinction between energy importers and exporters. In parts of Africa, countries such as Kenya and Ghana are facing mounting currency pressures and rising fuel costs, exacerbating existing macroeconomic vulnerabilities. By contrast, some Latin American economies with significant oil production capacity are experiencing relatively less strain and may even benefit from higher prices in the short term.

However, even for these more resilient economies, the broader financial environment poses challenges. Periods of global uncertainty are often accompanied by capital outflows from emerging markets, as investors retreat to perceived safe havens. This dynamic can lead to currency depreciation, tighter financial conditions and higher borrowing costs.

Taken together, these developments illustrate the multifaceted nature of the current shock. What began as a geopolitical conflict is rapidly evolving into a complex economic event, with implications that span energy markets, monetary policy and global capital flows. The absence of a clear resolution path only adds to the difficulty of assessing its ultimate impact.

IMI International Monetary Review

Central Banking in an Age of Global Supply Shocks *

By ŞEBNEM KALEMLI-ÖZCAN *

The core assumptions underlying the decades-old inflation-targeting orthodoxy have proven to be unfit for a geopolitically fragmented world characterized by frequent supply-side disruptions. Under such conditions, central banks' traditional monetary policies are only as effective as markets believe them to be.

TOKYO—As G7 finance ministers were meeting in Paris this month, the bond market was telling us what their official communiqués would not. The 30-year US Treasury yield touched 5.2% on May 19—the highest rate since 2007—while Germany's 10-year Bund hit a 15-year high and the 30-year Japanese government bond set a fresh record of its own.

These movements came after the US Federal Reserve decided, in April, to hold rates at 3.5–3.75%, with the Federal Open Market Committee more divided than it has been in three decades. Across the Atlantic, markets put the odds of a European Central Bank rate hike by December at 85%. After five years of being told that inflation was transitory, then conquered, then transitory again, investors have concluded otherwise.

Monetary policy is operating in a new environment, under conditions that are fundamentally different from those in which modern inflation targeting was designed. The orthodox framework was built for a world in which most macroeconomic shocks affected demand, aggregate or sectoral supply disruptions were small enough to "look through," and central banks could rely on a stable Phillips curve linking aggregate labor-market slack to weaker inflation. Unfortunately, none of those assumptions are fit for a geopolitically fragmented world characterized by frequent supply shocks.

Consider the COVID-19 experience. In a June 2022 presentation for the ECB Forum on Central Banking, my co-authors and I examined inflation in terms of aggregate demand, sectoral demand, and sectoral supply shocks. The result that surprised most readers—though it should not have—was that over two-thirds of eurozone inflation between late 2019 and late 2021 originated outside the eurozone, having been transmitted through global production networks.

Supply-side disruptions in foreign sectors, propagated by input-output linkages and amplified by the consumption shift from services to goods, accounted for the bulk of the price pressure. Domestic aggregate demand mattered, but not nearly as much as the policy debate assumed. The interaction between aggregate demand and sectoral supply shocks was more relevant.

In a scenario where supply is constrained, the global production network is granular (meaning it comprises many firms of different sizes spread across many sectors and locations), and demand is elevated via fiscal or monetary stimulus or booming stock markets, more inflation is produced than in a non-supply-constrained economy. Policies to manage aggregate demand cannot eliminate distortions in global networks, because monetary policy is a national instrument. As the inflation-output trade-off worsens, achieving disinflation becomes more expensive.

During the 2022–24 disinflation episode, the Fed hiked the benchmark federal funds rate 525 basis points in 16 months, going faster and further than any G7 peer, and US inflation duly fell from a peak of 9.1% in June 2022 to roughly 3% by mid-2023. Because the ECB was slower to start tightening and constrained by a weaker recovery and an energy shock (linked to the Russian invasion of Ukraine) it could not control, eurozone disinflation took longer. And in the United Kingdom, which faced the greatest energy-passthrough pressure, the process took longer still.

Conventional narratives credit these differences in the speed of disinflation to differences in the underlying inflation mix. But that is not the whole story. The more important factor was central-bank credibility. Long-run inflation expectations in the US barely moved off 2% because the Fed convinced markets that it would do whatever was necessary.

Credibility, in other words, did most of the heavy lifting. The actual rate hikes mattered less than the market's belief that more would come if needed. There is only one mechanism whereby monetary policy can stabilize supply-side inflation cheaply: by ensuring that no one will bother to price in a wage-price spiral, because everyone knows that the central bank would never tolerate one.

That is why the current configuration is so much more difficult than the last one. In 2022, central banks faced two supply shocks—the pandemic and Russia's full-scale invasion of Ukraine. In 2026, they face a

* The article was first published on on *Project Syndicate* on May 29th, 2026.

* Şebnem Kalemli-Özcan, Professor of Economics at Brown University and Director of the Global Linkages Lab, is a former senior policy adviser at the International Monetary Fund.

sequence that came on top of these previous shocks: tariffs followed by the Iran war. The US government's attacks on central-bank independence thus could not have come at a worse time. Some 62% of fund managers now expect the 30-year Treasury yield to reach 6%, not because they are forecasting Fed incompetence, but because they can see the constraints the Fed is operating under.

We have seen this movie before in emerging markets. In Turkey, sustained political interference in monetary policy pushed inflation from under 20% in 2021 to above 80% in 2022, unleashing a cycle that could be reversed only with extreme measures and significant pain. And Argentina, of course, has been pressing repeat for decades.

The mechanics are always the same. The central bank loses the freedom to react ahead of inflation expectations; it remains behind the curve, and the cost of disinflation rises by an order of magnitude. The point of ensuring that you have a credible central bank is precisely that you do not have to find out how much credibility you have when it really counts.

Bond markets are telling us three things. First, inflation is no longer a discrete problem to be solved at the national level; it is global in nature, reflecting frequent supply shocks in an economically fragmented world. Second, fiscal stimulus in the face of today's supply shocks is the worst possible response, and one that monetary policy alone cannot offset. And third, central-bank independence is less costly to defend when it is not yet under threat, and more expensive to rebuild after it has been lost.

Markets have seen the writing on the walls. Governments must open their eyes, too.

Geo-Economics

The World Economy After the Trump-Xi Summit ☆

By SHANG-JIN WEI *

If Donald Trump and Xi Jinping's Beijing summit produces a sustained Sino-American trade truce and a path to reopening the Strait of Hormuz, that will give the world economy something it has lacked for the past year and half: a reduction in tail risks. In a year when so much has gone wrong, that is a welcome prospect.

The optics of this week's summit between Donald Trump and Xi Jinping were carefully staged to signal parity between the United States and China. Trump, the first US president to visit mainland China in nearly a decade, was accompanied by an entourage of American CEOs—including Tesla's Elon Musk (with his son X), Apple's Tim Cook, Boeing's Kelly Ortberg, and Nvidia's Jensen Huang—whose businesses rely on maintaining good relations with the People's Republic. They were duly given a grand welcome in the Great Hall of the People.

But the summit's (less photogenic) substance may matter more. If the meeting cements two outcomes—a longer-lasting Sino-American trade truce and a path to reopening the Strait of Hormuz—it will give the world economy something it has lacked for the past year and a half: a reduction in tail risks.

On the matter of trade, the October 2025 Busan agreement between the US and China did halt implementation of most of Trump's punitive tariffs, with China agreeing to ease its rare-earth export controls. The economic implications of a summit-level agreement to extend this truce through 2027 would be difficult to overstate. China processes roughly 85% of the world's rare earths and over 90% of its rare-earth magnets—inputs in every electric vehicle, wind turbine, F-35 fighter jet, and Nvidia AI accelerator (an advanced data-processing platform). A stable supply removes a binding constraint on multiple Western industries at once.

The likely winners are easy to identify. Boeing, starved of Chinese orders since 2019, may finally receive the type of headline-making aircraft purchase that Trump can boast about back home. Apple would gain a more reliable supply of rare-earth magnets for everything from speakers to camera modules. Tesla would benefit from clearer rules for its Shanghai gigafactory, which now produces more than half of its global output. And American farmers—a constituency Trump cannot ignore—would regain access to the Chinese soybean and grain import markets, which quietly redirected their orders to Brazil and Argentina.

For China, the most immediate benefit is greater predictability. The greatest costs incurred over the past year and a half came not from any particular US policy or statement by Trump, but from the cloud of uncertainty that he has cast over the global economy. A stabilized regime would allow for companies around the world—not least Chinese exporters—to resume normal corporate planning.

The second potential dividend concerns the Strait of Hormuz. The International Energy Agency has described Iran's effective closure of the Strait as the largest supply disruption in the history of the global oil market. The global oil price is now about 50% higher than it was before the US-Israeli war on Iran began. Roughly 20% of seaborne oil and liquefied natural gas normally pass through the Strait, and in 2024, 84% of that crude went to Asia, with nearly 70% destined for China, India, Japan, and South Korea.

Thus, the pain has been unevenly distributed. Bangladesh faces what some analysts describe as recession-like conditions. Pakistan and Vietnam are rationing energy. Asian airlines have surcharged fares in response to higher fuel costs. And with over 30% of urea normally routed through Hormuz, fertilizer prices have raised food-security alarms from Cairo to Manila.

If the summit creates the conditions for a sustainable reopening of the Strait—with China pressuring Iran as its largest oil customer, and the US lifting its counter-blockade of Iranian ports—the global economy would regain roughly one-fifth of its hydrocarbon supply. The worst-hit emerging economies would benefit immediately from lower oil prices, fertilizer costs, and shipping insurance premiums.

☆ The article was first published on *Project Syndicate* on May 15th, 2026.
* Shang-Jin Wei, a former chief economist at the Asian Development Bank, is Professor of Finance and Economics at Columbia Business School and Columbia University's School of International and Public Affairs.

Still, three caveats are in order. First, China's relaxation of its rare-earth export controls will remain partial, in order not only to deter future US tariff escalations and export controls, but also actions by Europeans and others to support such US measures or introduce their own. To prevent others from building up large stockpiles, China will probably maintain sufficient rare-earths exports to support current use, but not strategic hoarding.

Second, whatever happens with the Strait of Hormuz will rest on a ceasefire that has proved fragile. Iran has demonstrated that it can close Hormuz at will, and that knowledge will not be unlearned. Lastly, any bargain struck at the summit could be undone when America's famously mercurial president returns to Washington.

In any case, the most important result of the summit may be one that the headlines miss. For a year and a half, corporate decision-making—about where to locate plants, how much inventory to carry, which suppliers to diversify toward, whether to hire—has assumed that the global trading system is progressively fragmenting. The costs of this calculation are evident everywhere, from the Chinese auto giant BYD's new plants in Thailand and Vietnam, to TSMC's $165 billion commitment to a semiconductor fab in Arizona, Apple's shift of iPhone assembly to India, and the duplication of capacity across many other sectors.

A stable US-China economic relationship would not reverse those decisions (many geopolitical considerations are here to stay), but it would slow the next round of fragmentation. Firms that have been building two of everything could strike a better balance between efficiency and resilience.

Trump's trip to China, and Xi's planned visit to the US in September, will not end the era of strategic competition. But if these summits lower the probability of accidents or escalations—an expansion of the US chip embargo, a sudden stop of rare-earth shipments, or a shipping crisis spiraling into something worse—they will have done more for the world economy than most recent summits have. In a year when so much has gone wrong, that is a welcome prospect.

IMI International Monetary Review

Cushioning the Middle East War Shock ☆

By KRISTALINA GEORGIEVA *

A resilient world economy is being tested again by the war in the Middle East. The conflict has caused considerable hardship around the globe. My heart goes out to all people affected by this war and all wars.

When we welcome ministers and central bank governors to our Spring Meetings next week, our focus will be on how best to weather this latest shock and ease the pain on economies and people.

This requires understanding the nature of the shock, the channels through which it affects the economy, the size of the impact, and the policies that can mitigate it.

So what hit us? A supply shock that is large, global, and asymmetric:

It is large because the world's daily oil flow cut by some 13 percent, and its LNG flow by some 20 percent;

It is global because all of us now paying more for energy and with supply chains disrupted across the world;

And it is asymmetric because its impact depends on proximity to the conflict, whether you are an energy exporter or importer, and your policy space.

As always, a negative supply shock pushes prices up. As a point of reference, Brent jumped from $72 per barrel on the eve of hostilities to a peak of $120. Thankfully, oil prices have fallen, but they remain much higher than before the war—and many countries are paying high premiums for access to precious supplies.

Spare a thought for the Pacific Island nations at the end of a long supply chain, wondering if fuel will still reach them in the wake of such a severe disruption.

The supply interruptions have had—and will for some time continue to have—ripple effects, such as:

Oil refinery disruptions given the need to maintain minimum flow rates, with warning lights flashing red in many far-flung places;

Shortages of refined products including diesel and jet fuel, which have disrupted transportation, trade, and tourism in a world more interconnected than ever;

Food insecurity for another 45 million people given the transport issues—taking the total number of people in hunger to over 360 million—with the problem potentially worsening over time because of higher fertilizer prices;

And supply chain disruptions given industrial dependencies such as on sulfur, helium for silicon chipmaking and MRI imaging, and naphtha for plastics.

The second question is: how can this shock play out? Through three main channels:

First: the price impact and supply shortages. Higher prices for key inputs feed into many consumer goods, lifting inflation. This, coupled with shortages, reduces demand by brute force.

Second channel: inflation expectations. These can break anchor and ignite a costly inflation process. Here is the distribution of near-term inflation forecasts for the U.S.; notice how the curve has moved to the right, indicating higher short-run inflation expectations. And here is the curve for the euro area; it also moves right, and it widens, indicating higher uncertainty. Fortunately, longer-run expectations have not budged—this is very good and very important.

Third channel: financial conditions. From a highly supportive starting point, these tightened, in an orderly manner. Emerging market bond spreads widened substantially; equity prices adjusted; and the dollar appreciated. And now we see some easing.

We have been here before in the 1970s and earlier this decade. We know eventually a significant part of the shock will dissipate, leaving us in a new equilibrium. Supply recovers and demand adjusts. New capacity comes on stream. Energy efficiency rises.

As proof, please appreciate how the world has become progressively less energy intensive since the 1980s, which cushions the shock. Renewable energy increased its share, yet oil remains our number one fuel.

As the world responds, it is important that we maintain our collective quest for energy efficiency and energy diversification. Different countries have different paths to energy security, but all must strive for it.

Let me move to the third question: how large is the growth impact?

The answer very much depends on whether the ceasefire holds and leads to lasting peace and how much damage the war leaves in its wake.

☆ Speech by Kristalina Georgieva at the 2026 Spring Meetings in Washington, DC, 9 April, 2026.

* Kristalina Georgieva, IMF Managing Director.

Given the uncertainties, our World Economic Outlook, to be published next week, will include a range of scenarios, going from a relatively swift normalization, to a middle scenario, to one where oil and gas prices stay much higher for much longer and second-round effects take hold.

All these scenarios start from a situation where strong AI and tech investment, supportive financial conditions, and other factors were driving considerable momentum in the world economy.

In fact, had it not been for this shock, we would have been upgrading global growth.

But now, even our most hopeful scenario involves a growth downgrade. Why? Because of significant infrastructure damage, supply disruptions, losses of confidence, and other scarring effects.

Take Qatar's Ras Laffan complex—a tremendously important example of strategic investment done right; producer of 93 percent of the Gulf's LNG, some 80 percent of it going to Asia-Pacific, a region that now endures serious fuel shortages. Ras Laffan has essentially been shut since March 2, took direct hits on March 19, and could take 3–5 years to restore to full capacity.

Even in the best case, there will be no neat and clean return to the status quo ante.

Another relevant fact: see how ship passages through Bab-el-Mandeb on the Red Sea have never quite recovered from the devastating disruptions there—they remain stuck at about half their 2023 level.

So the reality is, we don't truly know what the future holds for transits through the Strait of Hormuz or, for that matter, for the recovery of regional air traffic.

What we do know is that growth will be slower—even if the new peace is durable.

And we also know there are significant variations across the world. Countries able to export oil and gas undisturbed are the least affected. In contrast, countries directly disrupted by the war—including oil and gas exporters who suffered the blockade—and countries relying on imported oil and gas, still bear the brunt of the impact.

How bad this impact will be will depend, in no small measure, on how much policy space countries have, including oil and gas reserves, given the five-week gap we have seen in tanker traffic from the Gulf.

Let me walk you through a few key charts to illustrate three points of differentiation:

First, let's separate the world into oil importers on the left and oil exporters on the right. As the pile-up of dots on the left shows, over 80 percent of countries are net oil importers.

Second, let's highlight countries directly hit by this war. Note how the hits have disproportionately fallen on major oil exporters—although the red dots on the left remind us of the war's toll on regional non-oil economies as well.

Third, let us add a vertical scale for countries' sovereign credit ratings, as a proxy for policy space. The bottom left is where we find vulnerable oil importers. Let's color Sub-Saharan Africa in yellow, and small-island nations in orange. Notice how these two sets of countries largely fill that quadrant of vulnerability—they will very much be in our focus next week.

And yet, with oil being a global commodity, even oil exporters far from the affected region and enjoying terms-of-trade gains have felt the effects of costlier oil.

Let me move to the last question: what should countries do?

A word of caution upfront: this being a classic negative supply shock, demand adjustment is unavoidable.

Policymakers can help in multiple ways, and—certainly—they must be careful not to make things worse. So here I appeal to all countries to reject go-it-alone actions—export controls, price controls, and so on—that can further upset global conditions: don't pour gasoline on the fire.

Beyond that, as in past shocks, alertness and agility are key. The challenge will be to detect if and when changing conditions take us from one state of the world to another:

For now, there is value in waiting and watching, with central banks stressing their commitment to price stability but otherwise staying on hold—with a stronger bias to action if credibility is in question. Fiscal authorities should provide targeted and temporary support to the vulnerable, aligned with their medium-term fiscal frameworks.

Next, if inflation expectations threaten to break anchor and ignite a costly inflation spiral, then central banks should step in firmly with rate hikes. Fiscal support should remain targeted and temporary. Rate hikes, of course, would further dampen growth—that's how they work.

Finally, if a severe tightening of financial conditions adds a negative demand shock to the supply shock, then monetary policy returns to a delicate balancing act while fiscal policy—if and only if there is fiscal space—switches to well-calibrated demand support.

Let us have a quick look at what has actually been happening out there.

In monetary policy, markets have been expecting major central banks to tighten their policy stance. Here we see four key market-implied policy rate paths, each showing an upward shift.

In energy policy, we see many countries putting in place emergency conservation measures—from general campaigns, to limits on private vehicle use, to remote work. These and other steps are well-documented in the International Energy Agency's energy policy tracker, which is summarized here.

Such information-sharing, let me add, underscores why we have joined forces with the IEA and the World Bank to form a coordination group within which the IMF will lead on the macroeconomics.

And finally, coming back to fiscal policy, we see that most countries have appropriately held the line, avoiding untargeted tax cuts, energy subsidies, and price-based measures, although a few have chosen to deliver broad-based support. Again we see the IEA summary here.

We will point out that measures that mute the price signal also mute the necessary demand response, resulting in higher global energy prices. And we will work with countries to help them target their fiscal support and craft effective sunset clauses for temporary measures.

As we do so, we will also stress that it is important for fiscal and monetary policies to not pull in opposite directions.

Already, the world has seen benchmark yield curves rising, driving up the cost of debt. Adding deficit-financed stimulus to this mix at this moment would increase the burden on monetary policy and amplify such shifts. It would be like driving with one foot on the accelerator and one on the brake—not good.

As we will flag in our forthcoming Fiscal Monitor, the world has a fiscal space problem. Public debt is generally much higher than 20 years ago—including in most G20 countries—reflecting widespread neglect of fiscal consolidation in the periods when conditions permitted it.

As a result, interest payments are rising as a share of revenue at all income levels. The implication is clear: all countries must deploy their limited fiscal resources responsibly, and most must move decisively to rebuild fiscal space after this shock. I cannot emphasize this enough.

Let me move to financial sector policies. As our Global Financial Stability Report will insist, it is essential that financial regulators and supervisors be alert, nimble, and responsive to a fluid situation.

Financial conditions have been highly accommodative for some time, spurred by tech optimism and new financial intermediaries, many of them nonbanks. While this has lifted growth, it also creates risks of reversal. If investors were to start worrying about energy insecurity holding back the growth of AI, for example, given AI's huge energy needs, then we could find ourselves in a spot of trouble.

Micro- and macro-prudential policies must work to reduce financial stability risks and ensure a resilient system.

With that, I want to stress the most important lesson of all: good policies make a difference. There are forces countries can't control, but they do have authority over their own policies and institutions.

Take heed: the strength and agility of your fundamentals is your best defense when shocks come—and come they will.

And, as you deal with the long tail of the current shock, do not forget to steer the great global transformations in technology, demographics, geopolitics, trade, and climate and build a better future. Your structural and regulatory policy choices underpin productivity and long-run growth—and growth potential matters enormously for stability.

For us at the IMF, supporting you to build strong policies and institutions, this is our raison d'être. And, as the firefighter, we are here for you when crisis hits.

Once more, let's take into our lens the vulnerable oil importers of the world, those rated in the speculative grade, and let's color in blue all countries with IMF-supported programs. We can scale these programs up if needed and—be sure—there are more programs to come.

Given the spillovers of the Middle East war, we expect near-term demand for IMF balance-of-payments support to rise and to range from $20 billion to $50 billion, with the lower bound prevailing if the ceasefire holds.

Two points worth noting here. One, this range would be much higher were it not for the sound policymaking of many emerging market economies—including some of the largest ones—over the decades. And two, we are well resourced to meet this shock.

So, yes, our 191 member countries can count on us to support them with financing if needed. And they can count on us to bring them together to find a path forward through the fog of uncertainty. This is what next week will be about.

Thank you, and let us hope for lasting peace in the Middle East and everywhere—because war takes away everything that we work for.

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How to Navigate Geopolitical Turmoil in Central Banking? A European Perspective *

By OLLI REHN *

Ladies and Gentlemen, Dear Friends,

Thank you for the kind invitation to discuss with distinguished colleagues and an influential audience. Our discussion on the global environment of central banking could hardly be more timely – to my regret.

Today, the escalating conflict in the Middle East is no longer just a geopolitical concern and human tragedy - it is, as a deeply asymmetric war, an acute blow to the global economy, not least to the euro area, which is on the receiving end of the collateral economic damage caused by it. I have therefore revised my title to "How to navigate constant geopolitical turmoil in central banking?: A European perspective".

Geopolitics dominates the global economic outlook – uncertainty has yet again increased

Today, geopolitics affects every dimension of the economy - growth, inflation, financial stability and international cooperation. Both long-term megatrends, such as AI and climate change, and sudden political turns, such as the ongoing wars, are reshaping our operating environment.

And while all eyes look now to the Middle East, we should not lose sight of Ukraine. Ukraine is fighting not only for its own freedom, but for the security of Europe and the future of liberal democracy and civil liberties. Ukraine continues to need our support. And Europe must get serious about reinforcing its common defence, as NATO's European pillar.

Let me divide my talk into three parts. I shall first discuss the ramifications of the Middle East conflict and the energy crisis for the euro area economy. Second, I'll outline options for making monetary policy on the basis of the ECB's recently revised strategy. Third, I'll conclude with Europe's longer-term, largely structural economic challenges.

Oil prices are now over 50% higher than month ago – or at least were before I started this speech. Given the current volatility, I can't guarantee this is still the case. Natural gas prices have roughly doubled. For Europe, as a net importer of energy, this is a negative terms-of-trade shock.

We do not know how long the Strait of Hormuz will remain closed. We do not know how much damage has been done to production infrastructure. These factors will determine how long the shock to energy markets - and to the euro area economy - will last.

Despite the uncertainty, the near-term risk assessment is quite clear. Risks to growth are tilted to the downside. Risks to inflation are tilted to the upside. Inflation will increase this year, while economic activity will weaken. The medium-term effects, however, are still uncertain.

The ECB's monetary policy strategy of 2025 (and 2021!) particularly underlines our medium-term orientation. Our price stability objective is defined as a symmetric inflation target of 2% over the medium term. That matters to policy-making in the current context.

As a medium-term-oriented central bank, we keep a cool head and a broad perspective. What matters most is not the immediate increase in inflation, but whether the shock has persistent effects on inflation and general price level. That, in turn, depends on the source and duration of the shock and its potential second-round effects.

And it depends also on fiscal policy. Any fiscal measures should be temporary, targeted and tailored.

Right now, the outlook is very foggy. That is why we are putting so much weight on incoming data and continuous analysis with scenarios.

The good news for monetary policy is that we are facing this new shock at a time when inflation is close to target - 1.9% in February - and the euro area economy has shown resilience despite tariffs and geopolitics.

The euro area also has many decades of experience in dealing with different kinds of shocks. To provide some perspective, let me briefly review four periods of inflation in the euro era.

Four periods of inflation in the euro era, 1999–2026

In the first period, from 1999 to 2009, inflation was well anchored, near 2%. The euro area experienced steady growth during what was often called the "Great Moderation". This period marked the successful

* Speech by Mr Olli Rehn, at "The ECB and Its Watchers XXVI", organised by the Institute for Monetary and Financial Stability, Frankfurt am Main, 25 March 2026.

* Olli Rehn, Governor of the Bank of Finland.

build-up of the euro and the ECB's credibility. The target (since 2003) time was "below, but close to, 2%". Average inflation was 1.97%, which prompted President Jean-Claude Trichet to ask - with a bit of a grin - whether we could get any closer to the target than that. A good question.

But then the situation changed. After the financial crisis, for about a decade, inflation was clearly below target, around 1%. At times, there was even a risk of deflation - a fall in the general price level.

It was tackled by central banks with strong policy measures: very low or negative interest rates, long-term refinancing operations, large-scale asset purchases, and forward guidance. These measures supported the recovery, together with the strengthening global economy.

Then, in 2021, inflation accelerated sharply as the global economy reopened after the pandemic and production bottlenecks emerged. From February 2022 onwards, Russia's war and the energy crisis pushed inflation even higher, exceeding 10% in October 2022. Since the summer of 2022, monetary policy was consistently tightened, and inflation stabilised around the ECB's 2% target by 2024. Growth weakened, but the euro area avoided the worst-case scenario of stagflation.

In the fourth phase, from 2024 onwards, Europe has experienced stable inflation and modest growth. – Now we may again be on the brink of a new period of turbulence, as the Middle East is in turmoil and the energy shock once again hits the central nervous system of the global economy.

During these four periods, the drivers of inflation have changed - from demand-driven growth to global supply chains and energy geopolitics. And although we have seen energy shocks before, history does not repeat itself. Every shock is different. This time is no exception.

Which brings us to a familiar central banking question: should we look through an energy price shock, or should we react to it, even forcefully?

No two shocks/crises are alike

Research at the Bank of Finland shows that geopolitical shocks are complex, multi-channel events. They do not only raise oil prices. They also increase uncertainty, tighten financial conditions and disrupt international trade, which dampens growth. As a result, the medium-term effects on inflation are not straight-forward.

Many of us, no doubt, have in mind the 2022 shock following Russia's invasion of Ukraine. That is OK - but it is also worth being prudent. Not every oil price spike translates into the same inflation outcome.

For example, between 2011 and 2014, oil prices rose above 100 dollars per barrel due to strong global demand and supply disruptions related to the Arab Spring. Yet euro area inflation and core inflation remained low. Demand was weak at the time because of the euro area debt crisis, which limited the pass-through of energy prices to underlying inflation. Do I need to remind us that the ECB's two subsequent rate hikes of spring 2011 were reversed in November and December 2011?

The reason for the relatively limited pass-through at the time was not unique as such: the inflationary impact of an energy shock does not depend on the energy price move alone. It is also shaped by the broader macroeconomic environment: prevailing demand and supply conditions, existing price pressures, bottlenecks, expectations – and the extent to which the shock spreads beyond energy into the rest of the economy.

Thus, an energy price spike is always a drag, but its effect on overall inflation depends on the state of the economy which it hits. That's why we do closely monitor second-round effects and inflation expectations.

Households and firms still remember the inflation surge of 2022–2023, and this may influence expectations. Whether the current oil shock generates longer-term inflationary pressure will again depend on overall economic and labour market conditions. In 2022, rising energy prices coincided with strong post-pandemic demand. Now, in contrast, geopolitical tensions and tariffs are weighing on growth.

In line with the ECB's strategy, we analyse these risks using scenario analysis. Scenarios help us assess both upside and downside risks in a structured way. Every new day of war and every new destruction of energy infrastructure unfortunately brings us closer to weaker scenarios.

Yet, the key point is this: no two shocks are alike, and monetary policy must respond, from the standpoint of medium-term price stability, to the overall macroeconomic environment, not to oil prices alone.

Energy costs burden euro area industry

When we discuss the transmission channels of geopolitical shocks, we must also recognise a structural vulnerability in Europe: our continued reliance on imported fossil fuels. This affects both our resilience to shocks and our competitiveness relative to other major economies.

Europe has improved its resilience in recent years, and the share of fossil fuels in energy production has declined. In this respect, our situation is better than in 2022. But the energy transition is still ongoing, and energy costs for European producers have remained relatively high since 2022. We cannot avoid significant direct effects of the current energy shock on companies' production costs and households' purchasing power. All the EU member states have not used the past years responsibly to reduce their dependency on fossil fuels and to enhance their energy security.

The impact of the energy shock varies across countries, depending on how far the energy transition has progressed. Spain, for instance, has made solid progress thanks to determined policy action. In Finland, likewise, 95% of electricity production is emission-free - 55% renewables and 40% nuclear. This reduces the impact of energy price shocks. But in many other European countries, the buffers are smaller.

The Middle East war underlines that the green energy transition is essential for Europe's strategic autonomy and competitiveness - and for the climate. Slowing the green transition now would be a serious mistake.

Conclusions: Europe's strategic triple test

Let me now conclude.

Joseph Schumpeter once wrote that the state of the monetary system reflects the state of the nation. The same is true for Europe: the stability of the euro ultimately reflects the strength of the European economy and European society.

Today, Europe faces what I call a strategic Triple Test.

The first – and existential – test is security. Russia's war and changes in US policy have made one thing clear: Europe must take greater responsibility for its own defence. Common defence will also require common financing - and pave the way for European safe assets that can strengthen our capital markets and support investment.

The second test is energy and climate. The green transition is not a luxury. It is Europe's only credible long-term energy strategy. Energy security, competitiveness and climate policy now point in the same direction: clean energy, electrification, and energy efficiency.

The third test is growth and investment. Defence and green transition will require massive investment. If done right, these investments can also raise productivity and innovation. This is why completing the Savings and Investment Union is so important - and why we should set a clear and ambitious timetable, for example by 1 January 2028.

But above all, Europe must invest in its greatest strength: its people. Human capital - education, research, skills and innovation - is the true foundation of long-term prosperity. Talent will not come by accident. We need investment in education, smart immigration, and a culture that values science, innovation and responsible risk-taking.

So Europe's strategy is clear: invest in defence, invest in clean and digital transition, deepen capital markets, and invest in people.

With the right policies and a long-term perspective, Europe can turn today's challenges into tomorrow's opportunities.

Rest assured, monetary policy will do its part. We will keep inflation expectations anchored and ensure price stability over the medium term.

In a world of geopolitical shocks, this stability is more important than ever. We will provide a steady hand, which is in short supply today.

Thank you.

IMI International Monetary Review

The Hormuz Crisis and the Fate of the Global South⋆

By LAURA CARVALHO *

If the shock from the closure of the Strait of Hormuz has revealed economic vulnerabilities, it has also illuminated stark differences in how countries absorb energy-price turbulence. Those that have invested in more resilient clean energy sources are faring better and offering lessons for everyone else.

The closure of the Strait of Hormuz has triggered what the International Monetary Fund calls a "global yet asymmetric" rupture, disrupting the flow of roughly one-quarter of oil, one-fifth of liquefied natural gas, and one-third of fertilizer supplies. Energy and fertilizer prices have risen, supply chains have rerouted, and financial conditions have tightened unevenly around the world.

Import-dependent economies in Asia, Africa, and parts of Europe have been hit hardest, with many facing higher bond spreads and credit downgrades. As central banks weigh their responses to surging fuel and food prices, the rise in global interest rates is squeezing what little fiscal and policy space developing countries still have.

But if the "Hormuz shock" has laid bare economic vulnerabilities, it has also illuminated something else: the stark differences in how countries absorb turbulence. One of the most salient fault lines in the world nowadays is not simply between oil-exporting and oil-importing countries, but between countries whose energy systems leave them exposed and those who began building energy resilience long before the crisis arrived.

Spain's renewables revolution offers the starkest illustration of what is possible. Its rapid wind and solar growth has cut the share of hours in which gas sets the domestic electricity price from 75% in 2019 to just 19% in 2025—the sharpest reduction among Europe's major gas-reliant power markets. While wholesale electricity prices in Germany and Italy have been well above €150 ($177) per megawatt-hour during the Hormuz shock, Spain's average wholesale price for 2026 is projected to be €60–70/MWh.

Brazil's extensive biofuels infrastructure has provided a similar buffer, though by a different route. Tens of millions of Brazilian drivers can choose between 100% sugarcane-based ethanol or gasoline blended with 30% biofuel, supported by one of the world's largest fleets of flexible-fuel vehicles. Because domestic gasoline includes a substantial biofuel share, fuel refined by the state-run energy major Petrobras has remained dramatically cheaper than imported gasoline equivalents, cushioning consumers from global oil volatility. Brazilian gasoline prices rose just 5% in March, compared with roughly 30% in the United States, and Mexico's president has publicly expressed interest in Brazil's ethanol technologies, including agave-based production.

China, too, has proven more resilient than many would have guessed. After a decade of investment, renewables account for nearly 40% of its electricity generation, up from 26% a decade ago, and it has amassed strategic petroleum reserves of more than 1.2 billion barrels. As a result, Goldman Sachs has revised China's GDP growth forecast down by only half as much as that of the US, identifying renewable-energy dominance as one of the "shields" protecting its economy.

No wonder energy analysts are describing the Iran war as "Asia's Ukraine moment." Just as the Russian invasion of Ukraine in 2022 compelled Europe to reduce its reliance on natural gas, the Hormuz shock is pushing Asian countries to cut their oil dependencies. Moreover, cleaner alternatives are now significantly cheaper and more readily available than they were in 2022.

The lesson is clear: vulnerability is a function of structural and policy choices, not just of trade balances. Every country must ask how much of its energy system it controls, how diversified its supplies are, and whether it has built sufficient insulation between global commodity markets and ordinary people. For fossil-fuel-dependent economies that neglected the energy transition, there is an additional warning: if this crisis accelerates other countries' shift to renewables, stranded assets and shrinking export markets may compound the pain of future shocks.

As many governments wait for multilateral institutions to respond, realities on the ground are changing fast. At the same time, oil and gas producers have a rare window of opportunity. As the University of Massachusetts Amherst economists Isabella M. Weber and Gregor Semieniuk have argued, fossil-fuel price shocks are redistribution episodes: costs are imposed on the entire population while profits flow only to

⋆ The article was first published on *Project Syndicate* on April 14th, 2026.
* Laura Carvalho is Director of Economic and Climate Prosperity at the Open Society Foundations and Associate Professor of Economics at the University of São Paulo.

shareholders. That is why windfall profit taxes, such as the one recently championed by five EU finance ministers, are so urgently needed.

The additional revenues could serve two urgent priorities. The first is consumer protection. Higher energy prices are a regressive tax on the poor. Without active intervention, this crisis will deepen inequality within oil-exporting countries, just as it does elsewhere. Short-term subsidies, targeted energy vouchers, and price-stabilization mechanisms are legitimate uses of windfall receipts, precisely because the shock is temporary and the revenues will not last.

The second priority is structural investment. State-owned enterprises like Petrobras have already begun investing in biofuels and low-carbon technologies, and the Hormuz crisis could provide them with additional resources for this purpose.

Likewise, sovereign wealth funds offer a proven mechanism for institutionalizing the link between windfall revenues and long-term energy-transition goals. The Malaysian sovereign wealth fund, for example, has committed RM1.5 billion ($378 million) to decarbonize industrial parks and is building green investment platforms targeting renewable energy, storage, and e-mobility. Indonesia's new Danantara sovereign wealth fund has struck agreements to develop renewable energy and green hydrogen facilities, directly linking resource wealth to clean-technology value chains.

Even Senegal, a relatively small producer, has established the Renewable Energy and Energy Efficiency Fund through its sovereign vehicle FONSIS. It is mobilizing equity investments in renewables across the West African Economic and Monetary Union, as well as positioning itself to channel future gas revenues into green industrialization.

This is how countries shift from exposure to autonomy: by transforming yesterday's rents into tomorrow's capital base. Seizing this moment means converting temporary windfalls into durable assets and treating green industrial strategy as necessary for national resilience. The countries that act now will be glad they did when the next crisis arrives.

IMI International Monetary Review

The Geopolitical Battle Over Monetary Infrastructure ⋆

By CAMILA VILLARD DURAN *

The United States has raised the alarm about Brazil's instant payment platform, Pix. That is because the public scheme has highlighted the infrastructural basis of monetary sovereignty, which now hinges not on exchange rates and reserve currencies but on who designs and governs the rails on which finance moves.

The development of payment infrastructure in emerging-market economies (EMEs)—from instant payment systems in retail markets to wholesale central bank digital currencies (CBDCs) for cross-border interbank settlement—is part of a broader technological transformation. But the intense scrutiny these initiatives face from the United States suggests that what is at stake is not only technical supremacy, but monetary power itself.

Changes to how payments are executed imply a shift in control over the critical infrastructure through which money circulates, with consequences for the exercise of monetary sovereignty. While sovereignty in monetary affairs was traditionally understood as the authority to issue currency, it expanded over time to include oversight of banking systems and financial flows. In an increasingly digitalized world, however, sovereignty now hinges on the mechanisms underpinning payments and settlements, and the data generated by financial transactions.

This shift is especially visible in EMEs, where formal sovereignty has long coexisted with structural dependence. For years, the dollar's dominance has rested not only on its status as a global currency, but also on a dense network of privately governed infrastructure—the Society for Worldwide Interbank Financial Telecommunication (SWIFT), the New York Clearing House Interbank Payments System (CHIPS), and the Continuous Linked Settlement (CLS)—that shape how cross-border payments and financial settlements are conducted. Far from being neutral conduits, these US-dominated systems embed geopolitical power into the routine functioning of global finance, enabling "weaponized interdependence" through sanctions, exclusion, and control over financial flows.

Brazil's Pix is a case in point. An instant payment platform created and managed by the Central Bank of Brazil, Pix has rapidly become a central pillar of the country's financial architecture, surpassing payment cards in transaction volume. It embodies a governance model in which the state manages both payment rules and the data generated by transactions—an increasingly important source of economic and strategic power.

This has clearly spooked the US. The Office of the United States Trade Representative (USTR) opened an investigation into Brazil and included Pix in its 2026 National Trade Estimate Report on Foreign Trade Barriers under the broader category of "non-market policies and practices" that may generate "economic and national security risks" for the US. The report positions state-led payment infrastructure, data-localization measures, and digital regulations as potential distortions of competition that disadvantage foreign firms, particularly US financial-service providers.

But Brazil is not an isolated case. The USTR report expresses similar concerns about efforts in India, China, Indonesia, Turkey, Vietnam, Pakistan, Algeria, Oman, Kuwait, Qatar, and Thailand to develop domestic payment systems and strengthen regulatory control over digital and financial infrastructure, including through data-localization requirements.

This trend reflects a broader global shift toward a state-led approach to building financial infrastructure for the digital economy. Domestic payment systems, including Pix and India's UPI, should therefore be understood as part of a wider movement among EMEs to reclaim control over the rails on which money and financial data move.

Such a structural shift becomes even more consequential at the cross-border level, unlocking the potential for connecting domestic instant payment systems (like the Bank for International Settlements-led Project Nexus) and, crucially, using CBDCs for wholesale transactions.

Projects such as mBridge—bringing together China, Hong Kong, Thailand, the United Arab Emirates, and Saudi Arabia with initial support from the BIS—as well as emerging BRICS+ initiatives, illustrate how CBDCs can be used to redesign international payment infrastructure. By integrating messaging, clearing, and settlement, a single, state-governed platform may reduce reliance on traditional intermediaries and enable direct settlement in local currencies.

⋆ The article was first published on *Project Syndicate* on May 4th, 2026.
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More importantly, this approach embeds public authority into the technological architecture of payments and settlements, expressed in code, protocols, and governance rules. Monetary sovereignty, in this context, becomes infrastructural: it is exercised through the design and control of systems that support cross-border financial flows.

For EMEs, this represents a strategic opportunity. By reducing dependence on dollar-based infrastructure and enabling settlement in local currencies, multi-CBDC platforms and a standardized protocol linking domestic instant payment systems provide a pathway, albeit still limited, to expand the external dimension of monetary sovereignty.

To be sure, these developments do not signal the end of dollar dominance. The structural foundations of today's US-led system, from deep and liquid domestic financial markets to strong network effects and global demand for dollar-denominated assets, are robust. The rapid expansion of dollar-backed stablecoins may even reinforce this dominance in the digital realm.

But a more fragmented and contested landscape is emerging. The new initiatives are reconfiguring the existing system at the margins: creating alternative channels, redistributing power (albeit to a limited degree), and, above all, demonstrating that infrastructure, not currency, is the primary terrain of monetary competition.

This evolution has two important implications. First, future conflicts in the international monetary system are likely to center on standards, platforms, and data governance rather than exchange rates or reserve currencies. Second, EMEs are no longer merely passive recipients of global financial standards; they are becoming drivers of institutional and technological innovation.

In this context, the central question is no longer who issues money, but who designs and governs the infrastructure through which it moves. The answer will not be determined by technological efficiency alone. It will be shaped by law, institutional choices, and geopolitical strategy—and will ultimately define the future distribution of monetary power.

IMI International Monetary Review

A More Fragmented Global Economy Awaits After the Iran War [⋆]

By DENNIS SHEN [*]

Conflict, policy volatility and shifting alliances are redefining the global economic landscape

The war between the US-Israel and Iran marks a shift in the global order. Geopolitics is no longer a distant backdrop but rather a central force shaping economies – and a defining feature of Trump 2.0.

Even if many of the kinetic elements of the conflict may presently be on hold, expectations around stability, risk and policy-making have already been altered in ways that are likely to persist.

Although a ceasefire has been achieved, the more important question concerns what follows. Military conflict is costly, domestic pressures in both the US and Iran restrict the tolerance for continuing escalation and disruptions to trade and energy markets give rise to meaningful incentives for some level of stabilisation.

Yet, the path to any negotiated peace has proven fraught. Talks between Washington and Tehran have reportedly met obstacles amid disagreements over sanctions relief, regional security guarantees and the future scope of Iran's nuclear programme, while US President Donald Trump has continued publicly threatening renewed military action should negotiations falter.

From Tehran's perspective, any future arrangement must achieve more than temporary de-escalation. Iran seeks not only a deal, but also sufficient leverage to deter future military action from either the US or Israel. In that sense, its demonstrated willingness to disrupt Gulf economies and close the Strait of Hormuz may ultimately prove a more credible deterrent than the nuclear programme itself ever was.

Even after the war is behind us, longer-run fragilities appear inevitable. Recent diplomatic efforts increasingly resemble targeted confidence-building measures rather than any grand bargain – an outcome consistent with previous episodes of US-Iran diplomacy. Rather than heralding durable peace, the current trajectory points towards a delicate settlement designed to prevent immediate re-escalation while leaving many core tensions unresolved.

Regional fragilities

The war has deepened structural vulnerabilities across the Middle East region. Critical infrastructure – especially in energy production and transport corridors – has been exposed, while existing faultlines such as proxy rivalries and governance weaknesses may have been intensified. The region operates today with a meaningfully higher baseline level of risk. Disruptions are more likely, and their global economic effects more immediate.

Geopolitical alignments are evolving. Traditional alliances are giving way to more fluid and transactional relationships. Regional powers are hedging more actively, balancing ties across competing global actors rather than relying on any single partner such as the US. This reflects not just uncertainties around security guarantees but also the growing economic interdependencies between the region and both western as well as Asian economies.

External powers, meanwhile, are increasingly narrowing their focus to core interests such as energy flows and trade routes. Broader ambitions of regional stabilisation have given way to more selective engagements. The result is a more fragmented and less predictable geopolitical ecosystem, one in which coordination may be restricted and crises may be harder to contain.

Geopolitical risk and a moderating role of markets

One of the core lessons of the Iran war has been the degree to which economic and financial pressures have acted as a moderating force.

Markets have displayed a recurring pattern: sharp reactions to escalation followed by recoveries as rhetoric softens or policy shifts towards de-escalation. The ceasefire itself came following the tightening of financial conditions, meaningful rises in energy prices and mounting political pressure from economic fallout. This has seen a shrewd observation that the US president may be constrained by financial conditions – that sufficiently negative reactions prompt inevitable recalibration.

The market narrative commonly described as 'TACO' – shorthand for the perception that 'Trump Always Chickens Out' by escalating only to later soften or delay such threats – captures such a dynamic. Economic consequences, whether through financial markets, prices at the pump or electoral pressures, decisively shape

[⋆] The article was first published on IMF on May 15th, 2026.

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policy direction. In this sense, market sell-offs may paradoxically act as a counter-cyclical stabiliser, abetting near-term resilience and placing an informal floor beneath extreme outcomes.

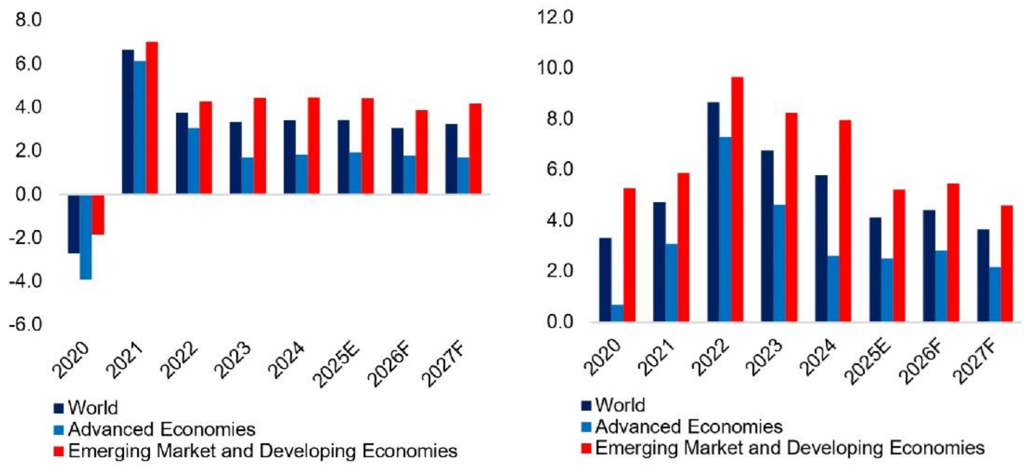
Nevertheless, this should not be overstated. Policy reversals are uneven, and the damage from escalation – lost confidence, deferred investment, weakened international coordination – can linger. Rather than delivering stability, such a dynamic risks entrenching a cycle of disruption followed by partial repair, leaving the global system incrementally more fragile.

The outlook in a more fragmented world

For the global economy, the near-term outlook remains the cautious story of resilience, albeit more contingent today on geopolitical events. The ceasefire provides some degree of near-term relief, even as oil inventories fall at record pace and borrowing rates have meaningfully risen.

The broader picture has been affected. According to the International Monetary Fund, the war has introduced a drag on global activity. Its latest projections place global growth at 3.1% in 2026 and 3.2% in 2027 – down from recent rates nearer to 3.4%, and below a pre-pandemic historical average of 3.7%. Notably, the 2026 forecast has been revised down by 0.2 percentage points amid heightened geopolitical and commodity-market pressures linked to the conflict. At the same time, global headline inflation is anticipated to rise to 4.4% in 2026 before easing to 3.7% in 2027, reflecting pressures from commodity markets as well as heightened uncertainty (Figure 1).

Figure 1. Global real growth (LHS) and headline inflation (RHS)%



Source: IMF World Economic Outlook, April 2026

Such figures underscore a salient point: absent the war, the global outlook would most likely have improved. Rather, geopolitical risk is serving as a headwind, offsetting tailwinds from technology investment, supportive policies and rises in equity markets.

The medium-run outlook remains meaningfully more challenging as the economic cycle matures and imbalances build. Elevated geopolitical risks are likely to weigh on investment, especially in exposed regions and sectors. Supply chains may undergo further reconfigurations as firms prioritise resilience over efficiency, raising costs and reducing productivity gains. Inflation may stay elevated, especially if energy markets were to remain sensitive to recurring geopolitical tensions or if significant supply disruptions inevitably re-emerge.

Enduring geopolitical shocks

The war has already accelerated structural shifts underway, such as energy diversification, higher defence spending and the development of alternative trade routes. Such adjustments might strengthen resilience over time, but they also reinforce a broader trend towards global fragmentation and reduced economic integration.

Ultimately, the legacy of the Iran war lies in how it has reshaped expectations. Geopolitical risks are no longer episodic but rather persistent, with policy less predictable and economic stability harder to sustain. The challenge ahead is not simply to recover from this conflict, but rather to adapt to a world within which such shocks are an enduring feature – and where resilience, rather than efficiency, becomes the defining principle of economic strategy.

IMI International Monetary Review

Global Trade

US-China Trade Truce Holds, But for How Long? ⋆

By SIMONA MOCUTA, ELLIOT HENTOV *

China's ballooning surplus risks new trade conflicts

A year after the 'Liberation Day' tariffs, the US–China trade relationship looks more peaceful than many expected. The constraints of mutual dependence have proven strong enough for both parties to keep the trade-war ceasefire. President Donald Trump's Beijing visit in May reinforced that impression, with both sides agreeing to build a 'relationship of strategic stability'.

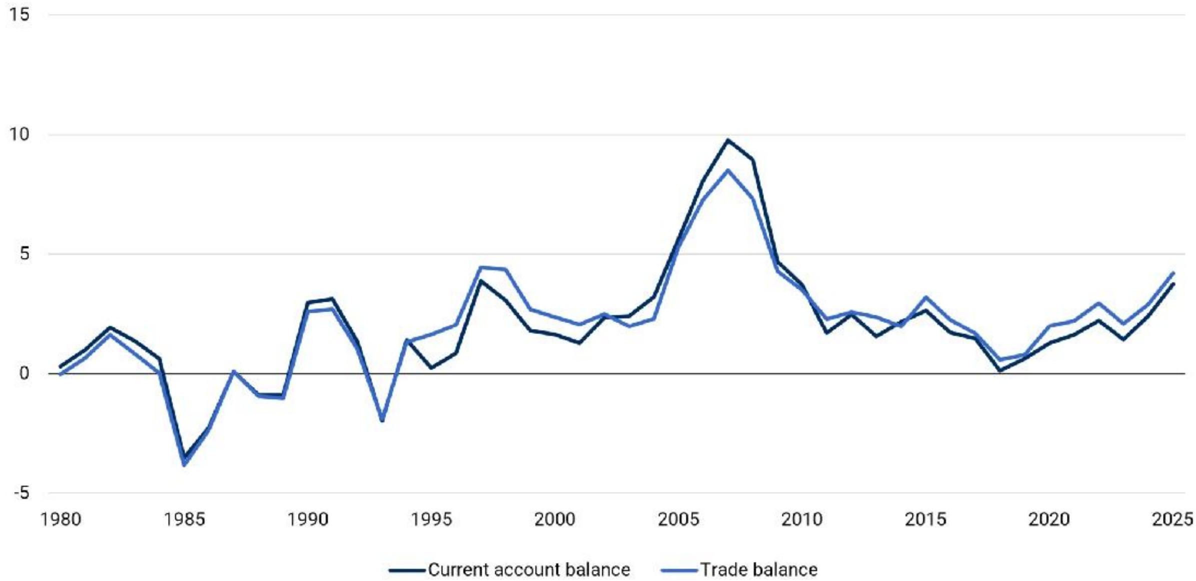
But as long as China perpetuates its overdependence on external demand, this can only be a stalemate, not a true end of hostilities. Other countries, meanwhile, may become more active in seeking to counter China's manufacturing dominance.

Imbalances continue to widen

Despite headwinds from US tariffs, China's 2025 trade and current account surpluses as a share of China's gross domestic product reached their highest level since 2009 (Figure 1).

Figure 1. China's external balances widen anew

% of GDP, as of 1 January 2025



Source: Macrobond, State Street Investment Management, Oxford Economics

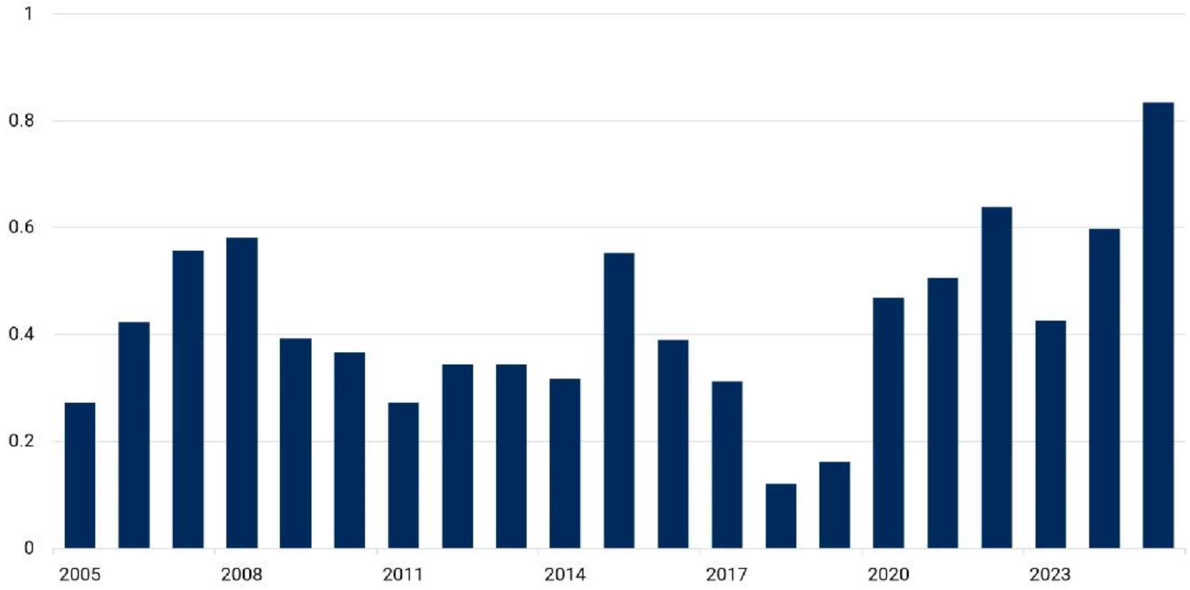
When assessed against global ex-China GDP (to adjust for China's growing weight in the world economy), the imbalance looks even starker. Last year, the rest of the world ran a trade deficit with China equivalent to 0.8% of its combined GDP, a new record high (Figure 2). By comparison, at the peak of Japan's manufacturing dominance, the rest of the world's trade deficit with Japan reached a one-time peak of 0.6% in 1986.

Figure 2. China's trade surplus reached new highs in 2025

China's trade surplus as a share of global ex-China GDP, %, as of 1 January 2025

⋆ The article was first published on OMFIF on June 5th, 2026.

* Simona Mocuta is Chief Economist and Elliot Hentov is Chief Macro Policy Strategist at State Street Investment Management.



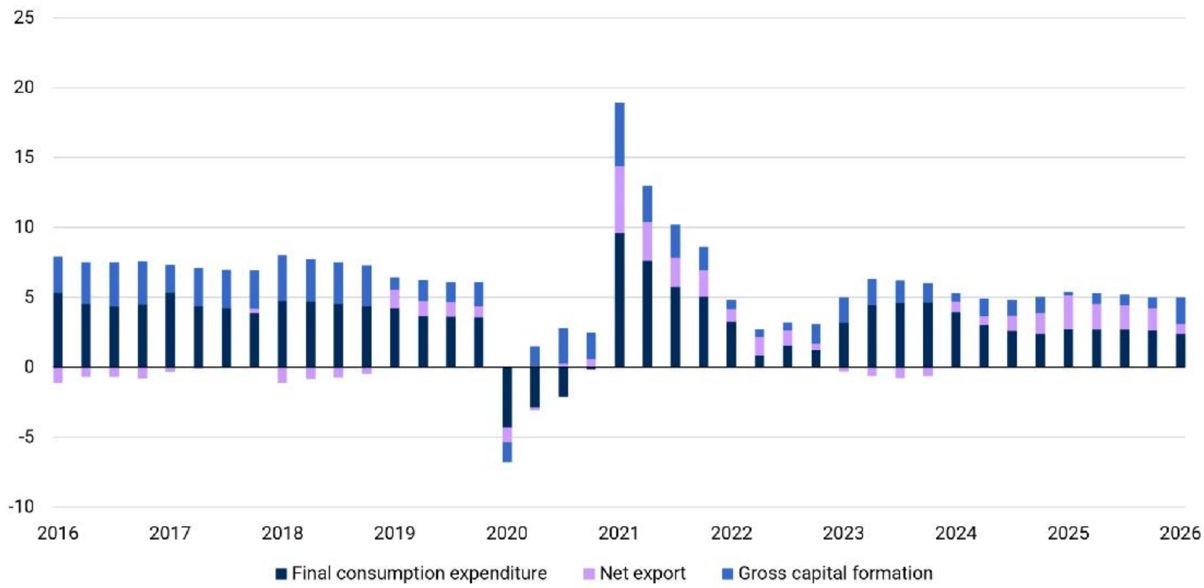
Source: Macrobond, State Street Investment Management, Oxford Economics

China's domestic demand deficit

China's external surpluses are the combined result of both its impressive manufacturing prowess on the one hand and its languishing domestic demand on the other. While China's growth rate has been relatively stable at around 5% over the last several years, trade has accounted for a larger share of that growth than had been the case before Covid-19. With the property sector still languishing, consumer spending seems unlikely to rebound meaningfully. If so, Chinese growth will either naturally moderate further, or external demand will have to continue to act as a bridge.

Figure 3. External demand still key driver of Chinese growth

%, as of 1 January 2026



Source: Macrobond, State Street Investment Management, China National Bureau of Statistics

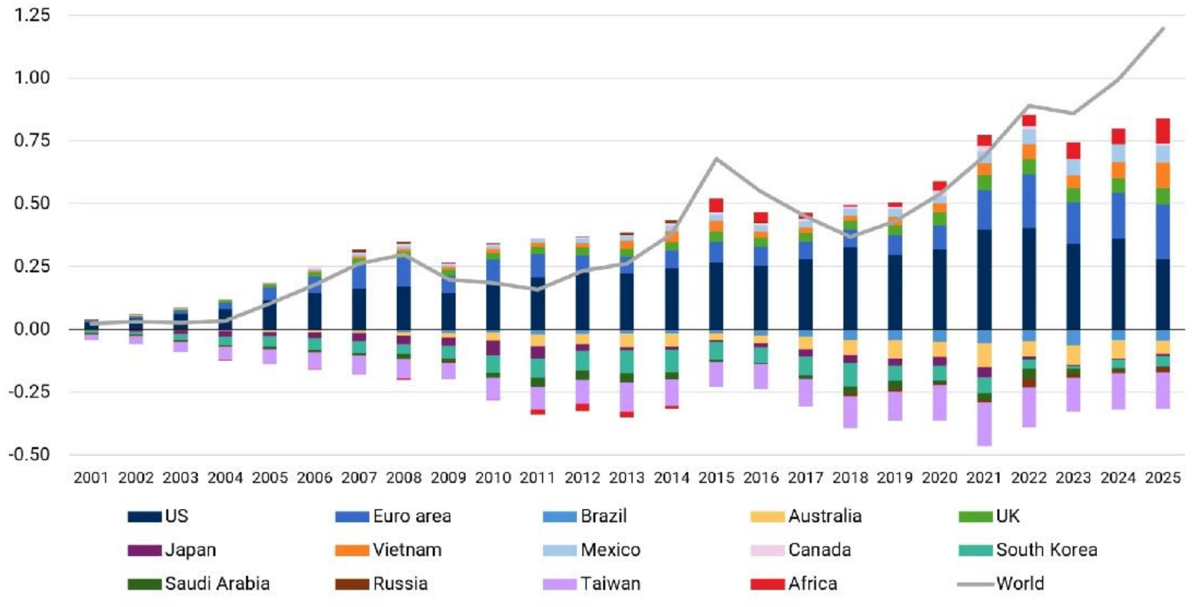
China's external surpluses are problematic

While this dynamic can temporarily work, if prolonged, it could become an existential threat to China's trading partners' manufacturing ambitions. The modest (though uneven) decrease in China's external imbalances that characterised the second half of the last decade has more than reversed.

Despite stated intentions to reorientate the economy towards domestic demand, there is no compelling evidence that this is occurring. Instead, the data suggest a geographical redistribution of a growing imbalance across a wider group of economies (Figure 3).

Figure 4. China's trade balance with select trading partners

$tn, as of 1 January 2025



Source: Macrobond, State Street Investment Management, International Monetary Fund

Is Europe the next front?

While China's trade surplus with the US has shrunk greatly in recent years, its trade surplus with the euro area has more than doubled since 2020 (from $95bn to $216bn). The relative shift is even starker. In 2020, China's trade surplus with the US was more than three times the size of its surplus with the euro area; by 2022, it was roughly twice as large. Last year, it was just 30% larger.

This is an extraordinary shift that does not appear to receive sufficient attention in European capitals, nor, for that matter, in many other capitals around the world.

On current trends, an EU–China trade war seems only a matter of time, though it may still take a while to snowball. Geopolitical fracturing means more reliance on domestic and regional demand everywhere. The US is a more closed economy than a decade ago, and Europe will have to follow suit.

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Navigating the Effects of Trade Protectionism ⋆

By WONG KAN SENG, ROBERT KOOPMAN, DANIEL PALOTAI *

Editor's Note: Geopolitical tensions and tariff wars are reshaping global trade dynamics and economic strategies. Recently, at the Boao Forum for Asia Annual Conference 2026, panelists held discussions under the theme "New Global Trade Landscape under Tariff Wars". Below are excerpts from the speeches of three panelists who were explaining how the world can tide over tariffs and increasing fragmentation.

Politicizing tariffs introduces uncertainty

Global trade has entered a new phase where geopolitical competition increasingly shapes economic decisions. Tariffs are no longer just economic tools, but instruments of statecraft with significant ripple effects. Tariffs affect us in three ways.

The first is the loss of predictability. Tit-for-tat tariffs erode planning certainty. Investment slows, partnerships become cautious, and trust weakens. Countries reassess whom they trade with and how exposed they are to geopolitical risk, reshaping global trade patterns.

Second, costs go up and supply chains get reconfigured. Tariff wars force rapid, expensive restructuring. Governments reduce strategic dependencies through subsidies, investment screening, and friendshoring.

Businesses diversify suppliers, build regional hubs, and sometimes duplicate supply chains — raising costs that hit smaller economies and the Global South hardest.

Furthermore, fragmentation amplifies the disruption as companies face conflicting regulatory regimes. Large firms are able to cope, but small and medium-sized enterprises struggle. Governments drift into competing blocs with divergent tech standards, digital systems, and parallel supply chains — pushing the world toward a bifurcated economy.

Tariff uncertainty acts like a hidden tax on global commerce. It delays investment, increases duplication, and adds regulatory friction. Governments lose policy space, businesses lose efficiency, and consumers lose affordability — all in an already fragile global economy. The World Trade Organization, once the anchor of predictable global trade, is struggling: negotiations have stalled, dispute settlement has broken down, and unilateral measures have surged.

To regain relevance, the WTO must adapt in three ways. It must restore trust through a functioning dispute settlement system. With the WTO Appellate Body paralyzed, confidence in rule enforcement has eroded. The Multi-Party Interim Appeal Arbitration Agreement — now covering 60 percent of global trade — keeps appeals alive and helps rebuild trust. It's not a full solution, but it reopens the "neighborhood court" and stabilizes expectations.

Second, the WTO should demonstrate that it can still write rules for today's economy. Digital trade, investment facilitation, and supply chain resilience define modern growth, but the WTO rule book remains stuck in the 1990s. Multilateral agreements — "coalitions of the willing" — allow progress without requiring full consensus. This flexible multilateralism is gaining support across major economies and keeps the WTO responsive to the challenges of the 21st century.

Lastly, the WTO must modernize rules in a way that feels fair to all members. Fairness means different things to different economies: updated rules for advanced economies, and policy space for developing ones. Balancing these expectations is essential for the WTO to remain relevant to both sides.

A credible dispute settlement system, flexible rule making, and a modernized, balanced rulebook are the pillars on which the WTO can operate effectively in a fragmented world. If these are achieved, the WTO can once again anchor global stability while supporting the regional integration that drives growth, especially in Asia.

If there is one lesson from the past year of tariff wars, it is that no country can navigate this turbulence alone. The global trading system is more polarized, more unpredictable, and more fragmented than it has been in decades. In this environment, regional cooperation is essential. Asia has a real opportunity to anchor stability in the post-tariff war landscape. By deepening regional integration, strengthening trade architecture and tackling the new frontiers of digital and green growth, this can be achieved.

Chain reaction of tariffs has greater impact

⋆ The article was first published on *China Daily* on April 2nd, 2026.
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It's really important to understand that tariffs are being applied in a very integrated global system. When you apply tariffs, or other trade-related policies, they propagate both upstream and downstream, through trade and input-output linkages in different countries and raise costs. This ultimately affects investment decisions. The uncertainty caused by these tariffs probably has a bigger impact on long-term economic growth than the actual increase in the tariffs themselves.

Tariffs and other trade policies often operate in ways that are typically not anticipated by their designers. When the United States imposed tariffs last year, the US administration probably did not realize that the move would not necessarily reduce the US trade deficit. In fact, the US trade deficit increased after the tariffs came into force. While direct trade from China decreased in products where tariffs applied, trade increased in products where tariffs did not apply. Moreover, China's indirect exports to the US through global supply chains actually increased in trade and value-added terms.

In a nutshell, global distribution centers and value chains are not retreating, but reorganizing following the increase in tariffs. Despite all these trade headwinds, global trade has remained resilient. Global trade actually grew 4.6 percent in 2025. Services grew even faster. The forecast is 4.8 percent in 2026, down from the 5.3 percent in 2025.

Some of that growth was due to US firms accelerating imports before the tariffs were increased in 2025. Additionally, China redirected its trade to other countries, which welcomed it extensively.

As the largest integrated trading region in the world, and the biggest regional trading bloc, Asia plays a stabilizing role in global trade. Its deep production networks have underpinned globalization and are now at the center of re-globalization. Agreements such as the Regional Comprehensive Economic Partnership and forums such as the Association of Southeast Asian Nations have a significant influence and provide a firm foundation for future economic growth.

Given the turbulence in global trade, what is the future of the WTO? I believe regional trade agreements have a great opportunity to provide innovations in multilateral rules. For example, the European Union can potentially play a big role here. Increased coordination and cooperation between members of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership and the EU can potentially counteract some US policies.

Having said that, it's important to recognize that trade policies are not the biggest drivers of trade growth. GDP growth, technological change and innovation play far more important roles in trade growth. Tariffs and other trade policies account for just 25 percent of global trade growth, while other economic factors drive the remaining 75 percent.

China has also experienced reasonably fast economic growth driven by other factors such as technological innovation, productivity growth, well-established rules and reduced uncertainty.

It needs to be acknowledged that these forces play a very dominant role in economic progress but there is a feedback mechanism. However, if the current uncertainty continues to rise and fragmentation increases, global economic growth could be negatively affected by these other forces.

Regional cooperation can mitigate tariff impact

From the perspective of small open economies, tariffs are reshaping global trade and weighing on the world economy in a long-term manner. Frequently changing trade policies and tariffs put pressure on global economic growth.

Despite the turbulence, the International Monetary Fund's projections for global growth are relatively stable. The IMF has forecast 3.3 percent growth in 2026, and 3.2 percent in 2027. However, these projections do not take into account any further escalation in tariffs or the impact of the conflict in the Middle East.

Tariffs mainly disrupt the supply side, leading to a reorganization of supply chains and production. This is evident in the recent regionalization and friendshoring trends.

Companies are facing higher costs due to tariffs, prompting them to relocate production to politically aligned or safer markets. This often results in less optimal resource allocation compared with the pre-tariff era, ultimately increasing costs and consumer prices.

Frequent changes in tariff measures introduce unpredictability and increase uncertainty for businesses. This uncertainty undermines the confidence and willingness of companies to invest, which impacts global growth potential. We also have to adapt to the long-term scarring of labor markets and economies.

Tariffs are likely to lead to parallel industrial ecosystems. Instead of a unified global economy, we are witnessing the emergence of competing regional ecosystems with different technological standards. This fragmentation may reduce overall global productivity and growth, increase costs for companies across regions, and create global inefficiencies.

For central bankers, this is a worrying prospect. We must be vigilant about the risk of financial instability, primarily stemming from increased market volatility and heightened risk premiums. This makes monetary policy decision-making particularly challenging. Monetary policies must strike a balance between the inflation target and financial stability. While inflationary pressures and higher risk premiums would call for tighter monetary conditions at higher rates, weaker economic performance and weaker labor market and employment figures would call for accommodative monetary policies and lower rates. These disruptions represent a delicate trade-off between inflation control and growth. Larger central banks may afford to be accommodative, but it is more challenging for small open economies.

How can we mitigate the effects of tariffs in trade wars? Regional cooperation could be one answer. The Regional Comprehensive Economic Partnership (RCEP) is the largest free trade agreement in history, and a prime example of how our regional alliances can help counter tariffs.

Regional cooperation is important, and the rules-based multilateral trading system remains irreplaceable and vital for managing global challenges. The dispute resolution mechanism of the WTO is particularly important for stable trade and corporate relationships. RCEP and future agreements between regional and Asian countries can help mitigate the impact of trade wars. This is exactly what we are working toward here in Boao.

IMI International Monetary Review

Climate Changes

Impacts of an Impending "Super" El-Niño on Global Supply Chains *

By LEIGH MANTE

Spotlight:

The projected El Niño is likely to yield asymmetric impacts; with drought-like conditions reducing maize, rice, and wheat production in Asia and Australia and wet conditions boosting global soybean production in the Americas.

El-Niño conditions hinder the clean energy transition by exacerbating heatwaves, draining hydrodams, and restricting access to mines due to flash floods.

Parametric insurance, adaptive measures, and infrastructure resilience will be crucial to buffer against shocks from conflict and climate interlinkages.

The El-Niño Southern Oscillation is a climate phenomenon oscillating between two phases: El Niño and La Niña, with each cycle spanning two to seven years. While La Niña induces cooling tendencies, El Niño increases global average surface temperatures. Historically , El Niño events have increased rainfall and flood risk in dry areas such as the Americas, while instigating drought in wet areas like South and Southeast Asia.

As the world forges through geopolitical upheaval, a prospective "Super" El-Niño, albeit a non-standardised classification, threatens to further destabilise global supply chains. The World Meteorological Organisation (WMO) predicts an upward shift in sea-surface temperatures in the Equatorial Pacific as early as May to July 2026, with an estimated 60 percent risk of El Niño development by summer. This trend is particularly alarming, as the looming El Niño will likely coincide with conflict-induced trade restrictions in the Middle East, which have already stranded maritime shipments, driven transpacific container rates 40 percent above pre-crisis levels, and restricted critical urea and phosphorus fertiliser exports.

The stakes are high, as the last dubbed "Super" El Niño invoked billions of dollars of losses , including US$327 million in the agricultural sector alone. Despite these risks, current studies highlight a deficit in forecasting effectiveness and strategic response capacity, often underestimating risk. This article evaluates projected asymmetric impacts of a Super El Niño across regional agricultural commodities, energy, and infrastructure, underscoring the urgent need for localised climate adaptation investments and measures.

Impacts on agricultural commodities

Drought conditions in South Asia, Southeast Asia, and Australia

Akin to previous patterns, El Niño is likely to induce drought-like conditions in Southeast Asia and Australia and a weaker monsoon season in South Asia, negatively impacting rice, grain, sugar, and palm oil production. For South Asia, the monsoon season is referred to as the region's " real finance minister ," as agriculture largely underpins regional GDP. India, for instance, estimates below-average monsoon rains for the first time in three years . Prolonged trade blockages of nitrogenous-based fertilisers through the Strait of Hormuz and dwindling options for viable fertiliser alternatives may result in potentially weaker yields for rice, cotton, and soybeans . Likewise, weakening rainfall across Thailand and Vietnam , the world's second and third largest global rice exporters, raises food security concerns for high-importing countries such as the Philippines where rice composes the bulk of caloric intake . Potential food insecurity is further exacerbated by intermittent rice and fertiliser export restrictions , dependencies on energy-intensive irrigation practices, and rising costs of cooking gas . Moreover, El Niño conditions are expected to exacerbate below-average rainfall in Australia, reducing wheat production and exports to Asia , placing pressure on domestic stockpile buffers.

Prolonged trade blockages of nitrogenous-based fertilisers through the Strait of Hormuz and dwindling options for viable fertiliser alternatives may result in potentially weaker yields for rice, cotton, and soybeans.

* The article was first published on *Observer Research Foundation* on May 12th, 2026.

Diverging impacts across the Americas

El Niño induces diverging impacts on North and South America, positively impacting soy production and negatively impacting coffee production. For instance, during El Niño events, average soybean yields improve by 2.1 to 5.4 percent , due to more favourable growing conditions in the United States (US), Argentina, and Brazil. Brazil's soybean harvests are progressing well due to rain from La Niña conditions , but El Niño could negatively affect 2027 crop production alongside fertiliser restrictions due to aforementioned conflict-induced trade blockages. Despite current strong crop output, Brazil has every incentive to leverage soybeans domestically for biofuels to shield the country from the US-Israel-Iran war fuel import disruptions . The country already seeks to increase its biofuel portion of diesel to 20 percent and high bunker fuel prices inhibit exports from reaching markets. In coffee-growing countries across the equator, El Niño also invokes dry conditions and heat stress , negatively affecting coffee yields and smallholder producer livelihoods . However, given previously record-high Brazilian coffee crop harvests , future coffee production is not expected to be seriously affected. The diverging contrast across geographies necessitates tailored response strategies among policymakers and international agencies.

Mixed impacts across the Middle East, South and East Africa

For the Middle East , a lingering El Niño threatens domestic water supply, with the potential for drought-related disputes to emerge in Iraq, Syria, and Lebanon. Compounded by ongoing conflicts, water scarcity, high fertiliser and fuel costs, El Niño conditions may threaten food insecurity and drain declining fiscal buffers. However, an El Niño also increases the risk for extreme heat, heavy precipitation and flash floods, testing the adaptive capacity of urban infrastructure. In Southern Africa , drought conditions may reduce regional maize production, while Kenyan maize crop production in the East may benefit from additional rainfall.

Impacts on the energy transition

Beyond agricultural commodities, severe weather disruptions also compromise energy distribution, creating a feedback loop that temporarily hinders clean energy transition efforts. A Super El Niño may intensify heatwaves , simultaneously straining water supplies and power grid connectivity, prompting increased fossil fuel dependencies. In India, a rise in electricity demand from El Niño conditions is expected to raise coal-fired power generation by 10 percent year over year, and the country is looking to leverage hydropower to fill the gaps. However, hydropower-dependent countries may be forced to reduce output or shut down due to droughts or torrential flooding. In Zambia and Zimbabwe, for instance, El Niño drought conditions previously reduced hydropower generation at Kariba Dam .

A Super El Niño may intensify heatwaves, simultaneously straining water supplies and power grid connectivity, prompting increased fossil fuel dependencies.

Beyond immediate power shortages, climate-driven energy disruptions intersect with Strait of Hormuz blockages, sharp oil price hikes, and infrastructure vulnerabilities, stalling critical minerals output across Global South countries. In Indonesia , where hydropower underpins mining operations, any shortfall in rain risks curtailing the country's nickel operations, affecting global steel production. These operations are further compounded by a disruption in sulphur feedstock from the Middle East which is crucial for purifying Indonesia's nickel supply . On the opposing end, El Niño increases heavy rain in Chile, inhibiting access to Chile's mountainous mining regions which house large copper deposits.

Impacts on maritime trade corridors

Drier El Niño conditions can also restrict maritime traffic. A decline in water levels from the previous El Niño resulted in reduced weight limits and increased vessel surcharges for shipments across the Panama Canal . Shipments were previously able to be rerouted through the Suez Canal, Strait of Magellan, and the Cape of Good Hope. With ongoing trade blockages at the Strait of Hormuz, added climate vulnerabilities may further complicate just-in-time supply chain operations. Likewise, the Suez Canal is already subject to coastal inundation. El-Niño associated rainfall shifts from the land to ocean could further exacerbate rising sea levels, compromising critical maritime infrastructure. Previous simulations highlight how small-island developing states (SIDS) would be the most negatively affected by increased shipping rates from geopolitical and climate disruptions at key maritime chokepoints, due to their heavy economic dependence on maritime shipping and processed food imports. SIDS are projected to experience a 0.9 percent consumer price impact, and a 0.11 percent reduction in real GDP, a figure doubles the global average. SIDS also have differing adaptive capacities to respond to shocks due to their economic structure, debt levels, and institutional capacity, with concentrated economies having lower adaptive capacity compared to diversified economies.

Looming El-Niño underscores importance of climate resilience measures

While increasing food and energy stocks and diversifying trade corridors are crucial to safeguarding economic growth amidst El Niño conditions, accelerating investments in climate insurance mechanisms and other resilience measures is equally crucial to protect vulnerable households, small-sector players, and infrastructure across agriculture, energy, and water management sectors.

Climate-related insurance schemes are already expected to rise by 50 percent by 2030, thus prompting the need to recalibrate insurance to incentivise resilience approaches.

First, parametric insurance schemes can help mitigate financial impacts of extreme El Niño conditions on vulnerable populations. Climate-related insurance schemes are already expected to rise by 50 percent by 2030 , thus prompting the need to recalibrate insurance to incentivise resilience approaches. Peru piloted an El Niño Index Insurance which determines pay outs through a pre-defined index instead of physical flooding or drought damages. By releasing payouts prior to the heaviest flooding and rainfall, communities or companies are offered funding earlier on to reinforce infrastructure, shift planting schedules, or harvests, allowing them to mitigate potential losses as opposed to reacting to damage. Likewise, Colombia also released a parametric insurance solution which reacts to predefined weather change thresholds to help smallholder coffee households recover from climate shocks. Several limitations of parametric insurance include a lack of compensation to losses just above or below the predetermined threshold and the increasing frequency of insurance payouts associated with intensifying climate risks.

Second, embedding resilience considerations in crop and infrastructure planning is crucial to mitigate risks and lower costs. Often, policies for slow onset climate events such as El Niño are incomprehensive and fragmented. For the agricultural sector, impacts on crop output often depend on timing, intensity, duration, and intersection with growing and harvest seasons. Thus, supporting small-scale farmers to pre-emptively develop alternative crop value chains and monitor changes in water salinity will help them prepare for extreme drought or flooding events. FAO analyses suggest that every US$1 invested in anticipatory action adds US$7 in value of avoided losses and added benefits for families. For urban infrastructure , combining enhanced localised weather monitoring for extreme heat or flash flooding with grey and green infrastructure solutions, stormwater management, and land-use regulation will help reduce cascading repercussions. For the maritime sector , establishing backup trade routes during drier months can help prevent stranded goods, while strengthening investments in maritime infrastructure resilience significantly reduces high transport costs. A UNCTAD analysis found that an investment-to-export ratio in maritime transport infrastructure that improves from the bottom 20th percentile to the 20th-40th percentile group would decrease maritime costs by 4.7 percent.

Embedding resilience considerations in crop and infrastructure planning is crucial to mitigate risks and lower costs.

The forthcoming “Super El-Niño” threatens to exacerbate compounding crises wreaking havoc on global food and energy supply chains. The increasing need for climate-resilient infrastructure to buffer against the incoming volatility of conflict and climate interlinkages is already driving 2026 green bond deployment and cargo war risk insurance . However, ensuring that finance translates to resilient infrastructure development will be crucial to reducing food insecurity, clean energy disruptions, and disproportionate cost burdens.

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The Right Incentives for Climate Action *

By PAULA CARVALHO PEREDA *

As the closure of the Strait of Hormuz continues to disrupt global oil and gas flows, countries are increasingly focusing on short-term energy priorities to the detriment of long-term decarbonization goals. In such a context, the difficult task of designing climate policies that realign incentives takes on new importance.

As wars reshape global energy markets, short-term priorities—from securing fossil-fuel supplies to subsidizing energy consumption—are increasingly clashing with long-term decarbonization goals. After Russia's full-scale invasion of Ukraine, Europe scrambled to find alternative sources of liquefied natural gas, boosting investment in new fossil-fuel infrastructure. The closure of the Strait of Hormuz has led other countries, such as those around the Atlantic Basin, to expand domestic oil and gas production.

These decisions, while understandable, illustrate how global shocks can entrench carbon-intensive systems. Beyond the issue of increased emissions, any fossil-fuel infrastructure built today will operate for 30–40 years, raising the risk of stranded assets and the costs of future decarbonization efforts. The disruption caused by recent conflicts has also shifted political attention away from climate commitments.

Seen in this light, climate change is a problem of incentives and trade-offs. When drivers fill up their gas tanks, they pay for the fuel, but not for its negative externalities, such as global warming and its effects on vulnerable communities and future generations. Because emitters do not bear the full costs of their choices, they emit more than is collectively desirable. Left unaddressed, markets will under-provide climate stability, just as they do for other public goods like clean air or health care.

Policymakers can correct this market failure mainly through pricing mechanisms like carbon taxes, emissions trading systems, or command-and-control policies. These measures seek to influence individual and corporate choices: market-based instruments allow businesses and households to find the cheapest way to cut emissions, while regulatory constraints impose standards or limits (and can therefore be easier to enforce).

The benefits of these climate policies are shared globally, but their costs are borne locally and nationally. This creates an incentive to free ride on others' efforts to reduce emissions, which becomes stronger when geopolitical pressures make energy security the overriding priority. In such a context, the difficult task of designing policies and mechanisms that realign incentives takes on new importance.

Brazil's experience shows that well-designed climate policies with reliable metrics and standards, as well as consequences for non-compliance, can have a big impact. In the 1980s, a spike in the number of infants born with anencephaly in the Brazilian city of Cubatão was attributed to uncontrolled industrial pollution. In the wake of this and other public-health crises tied to extreme pollution, the national environmental ministry devised the PROCONVE program, a vehicle-emissions standard that required automakers to produce significantly cleaner cars. After implementing the policy, Brazil observed a substantial reduction in vehicular emissions. A command-and-control policy worked as intended—setting a clear standard, applying it uniformly, and measuring the results.

Brazil also found a way to alter incentives in the Amazon, which, by 2004, had already lost roughly 15% of its rainforest (an area the size of Ukraine), owing to insufficient monitoring and enforcement activities. The federal government began to use satellite imagery from the National Institute for Space Research to measure deforestation reliably, enabling enforcement almost in real time. This formerly lawless zone became governable. The result was a roughly 85% decline in Amazon forest-clearing rates within less than a decade, cutting national emissions significantly.

In addition to pricing and regulation, information-based policies are a powerful tool for raising awareness about the social and environmental costs of individual choices and making social norms visible. Brazilian data show that substituting fish for meat one day per week could reduce household food-related emissions by 11% without increasing costs—information that could significantly reduce total national emissions if it were internalized by households. Moreover, a 2014 study conducted in the United States found that home energy reports based on social comparison significantly reduced households' consumption.

When policy sets constraints—whether through carbon pricing, performance standards, regulatory frameworks, or public investment—markets find the most efficient way to meet them. Markets are not the problem; unregulated externalities are. So is the lack of global coordination, which can be solved by carbon border adjustments that penalize free riding, climate clubs that reward participation, and technology transfers

* The article was first published on *Project Syndicate* on June 3rd, 2026.
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that lower the cost of compliance for poorer countries. Once policymakers correct these failures, markets become the solution.

The political headwinds against climate action have intensified, even as global temperatures reach record highs. Every year of delay compounds the costs of decarbonization. But just because some countries are stepping back does not mean others should give up. The future of the planet will be shaped by millions of individual and collective decisions. Change is still possible; the central challenge for policymakers is whether they are willing to design the incentives that make it inevitable.

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Sustainable Economies Will Own the Future ⋆

By BRUNO BOUYGUES, BERTRAND BADRÉ *

The COVID-19 pandemic and the wars in Ukraine and Iran have reframed the issue of sustainability, which is now as much about sovereignty and economic security as it is about planetary health. Countries and companies that fail to recognize this have everything to lose in the coming years.

Environmental and climate concerns appear to be in retreat worldwide. The word sustainability has become politically charged, the Trump administration openly mocks corporate ESG (environmental, social, governance) criteria, and many companies are shelving their net-zero-emissions pledges.

But look beneath the surface, and you will see something else. Though the political and cultural backlash against "sustainability" is real, so is the global economic transition toward cleaner energy technologies and electrification.

After all, the work of establishing corporate sustainability standards has continued. A growing number of jurisdictions are adopting the International Sustainability Standards Board's disclosure framework, and in Europe, the European Sustainability Reporting Standards remain in force. Despite their differences, such initiatives are converging into a single global architecture.

This convergence is driven not only by complementary regulations, but also by the world's largest pools of capital. Pension funds, sovereign wealth funds, insurance balance sheets, and development-finance institutions are increasingly bound by net-zero commitments, taxonomy-aligned reporting, and transition-risk frameworks.

This is no passing trend. We are witnessing a fundamental repricing, one that is being applied gradually through fiduciary and prudential decisions. Companies that can produce credible carbon-reduction strategies are recognized as investable assets, and often can borrow on more attractive financing terms. Those that cannot run the risk of being priced accordingly.

Such signals are unlikely to change. The COVID-19 pandemic and the wars in Ukraine and now Iran have reframed the issue of sustainability, which is now as much about sovereignty and economic security as it is about the planet. Reducing dependencies on fossil fuels is the most direct route to energy security, just as shorter supply chains build industrial resilience and circular material flows ensure strategic autonomy. Captains of industry and national-security strategists are increasingly reading from the same playbook.

Of course, the West has been slow to come to this realization, whereas China made a deliberate strategic choice years ago to become the world's leading sustainable power. China now manufactures roughly 80% of the world's solar panels, dominates battery supply chains, and is rapidly scaling up green hydrogen, offshore wind, and electric mobility technologies. Clean technology is the global economy's competitive frontier, and China intends to own it.

European and American manufacturers face a formidable, state-backed competitor; but the global energy transition is, by definition, an undertaking of enormous scale. The question is not whether that story will be written, but how many leading authors it will have.

Europe is well positioned here. It boasts deep industrial expertise, world-class engineering institutions, a sophisticated financial system, and—crucially—the world's most developed regulatory framework for creating sustainable products and mobilizing sustainable capital.

The European Green Deal, the Corporate Sustainability Reporting Directive, and the digital product passport are more than compliance regimes; they are the necessary infrastructure for building a sustainable industrial economy. Europe is the world's most demanding market. Any manufacturer that meets European standards holds a de facto credential that should be recognized anywhere.

Europe can treat this architecture as a defensive perimeter, or it can deploy it as an open platform. The latter path—working with Japan, South Korea, Canada, and willing emerging economies to build interoperable standards and share technical capacities—would position Europe as the convening authority of a genuinely global sustainable economy. That is a role worth playing.

But the global industrial transformation that is currently underway is not a matter of policy debate. It is part of a historical sequence. European industry has managed new quality-certification processes in the 1990s, sustainability ratings in the 2010s, and a steep tightening of product-level regulation through 2025. Now

⋆ The article was first published on *Project Syndicate* on May 19th, 2026.
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comes the fourth act, with the rollout of digital product passports, taxonomy-aligned financing, and carbon accounting in procurement. The recent political backlash has not—and cannot—reverse this trend.

Three implications follow for policymakers, industrial leaders, and financial institutions. First, manufacturers should be supported through the transition, not shielded from it. Europe needs a coordinated effort to help midsize industrial companies—the backbone of European employment and innovation—build digital and reporting capabilities, combining national development banks such as Bpifrance, KfW, and Cassa Depositi e Prestiti with private capital and mentoring programs. Subsidies that merely delay progress are not the answer.

Second, Europe's digital product passport should be treated as shared infrastructure, not as a compliance burden. The mechanisms for issuing, verifying, and exchanging product data across global supply chains will be for the new industrial economy what payment messaging networks are for finance. Europe can be a constructive standard-setter, but only if it works with its trading partners, not against them.

Third, European trade diplomacy should align with this regulatory architecture. Rather than treat environmental standards as bargaining chips, Europe should recognize equivalent frameworks where they exist and invite partners to converge on shared methodologies. The legitimacy of European standards rests precisely on their non-discriminatory character.

The companies that will define industrial competitiveness a decade from now are already completing their fourth act: ensuring digital traceability, adopting carbon accounting, aligning with taxonomy criteria, and turning compliance into a commercial advantage. They are emerging across France, Germany, Italy, the Netherlands, the United Kingdom, Japan, South Korea, and other partner economies.

Sustainability and competitiveness are not competing priorities. They are the same project, viewed from two angles. Recognizing that this convergence is not a passing fashion but a structural shift is essential to implement the economic and financial policies that are best suited to the frontier ahead.

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Ocean Resilience Means Financial Resilience ⋆

By MAUD ABDELLI, LOUISE HEAPS *

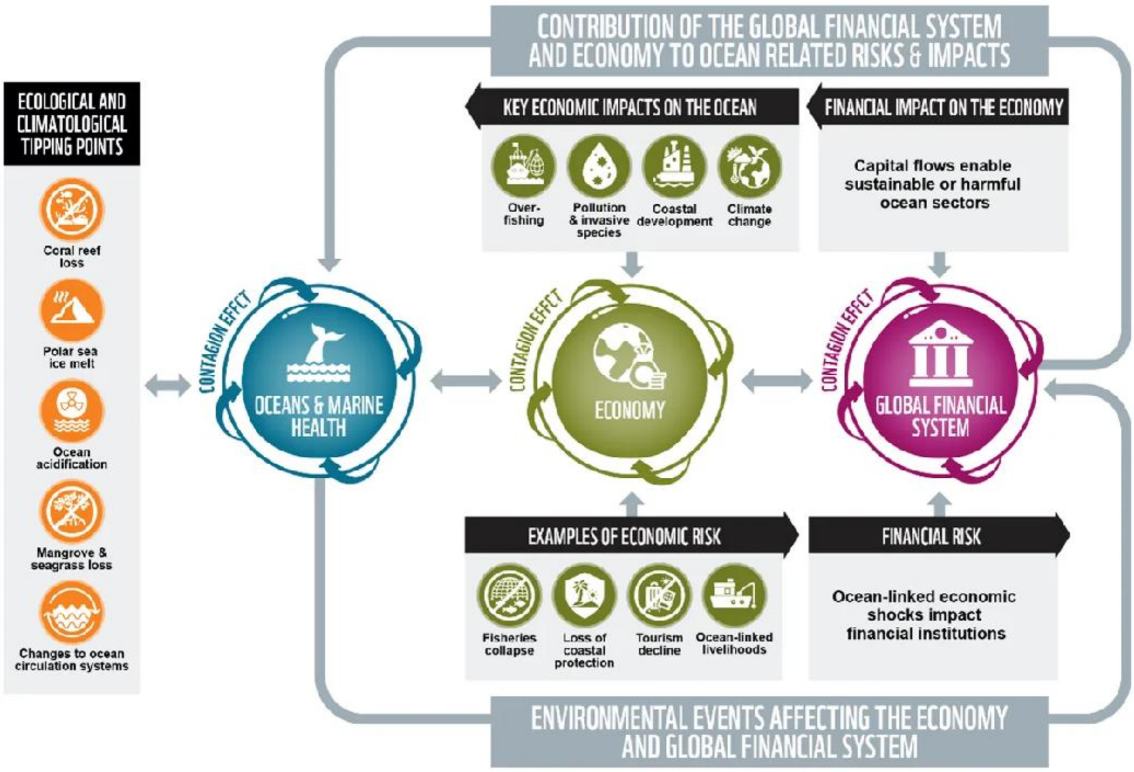
Aligning monetary and financial policy with a sustainable blue economy

The global financial system stands at a crossroads. The ocean, valued at an estimated $24tn in assets and generating $2.5tn in annual gross value added, is an essential pillar of macroeconomic stability. Yet, the health of this vast marine capital is under immense pressure from overexploitation, pollution, ecosystem degradation and the impacts of climate change. Its decline represents not only an environmental risk; it is a material macro-financial risk with direct implications for price stability, sovereign creditworthiness and the resilience of our financial system.

As stewards of financial stability, central banks, financial regulators and supervisors have a pivotal role to play in ensuring that the financial system supports, rather than undermines, the ocean's resilience.

A sustainable blue economy, one that safeguards and restores vulnerable ocean ecosystems while delivering social and economic benefits, requires a fundamental rethinking of how monetary and financial policy account for natural capital.

Figure 1. Transmission channels of ocean-related risks to the financial system



Source: Network for Greening the Financial System, Almeida & Reitmeier (2024) and WWF

Today, ocean-related risks and dependencies remain largely unpriced and invisible within financial decision-making. Harmful subsidies, poorly priced marine resources and an absence of ocean-related risk metrics continue to drive unsustainable marine sectors. Various scientific research shows that ocean degradation threatens to accelerate physical climate risks, disrupt global supply chains and increase volatility across financial markets.

Ecosystem tipping points – such as the loss of coral reefs from significant bleaching events or the potential disruption of the Atlantic Meridional Overturning Circulation – are highly likely to trigger abrupt, irreversible shifts with profound macroeconomic consequences. Correcting these distortions will demand a coordinated effort across fiscal, monetary and regulatory areas.

⋆ The article was first published on OMFIF on April 13th, 2026.
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For financial authorities, the imperative is clear: ocean health must be integrated as a core element in financial regulation and monetary policy, and should include a broader governance approach involving fiscal policies.

Financial regulators and central banks are increasingly recognising that climate- and nature-related risks have wide, systemic implications. The same logic applies to the ocean. Embedding ocean-related physical and transition risks into supervisory, macroprudential oversight and scenario stress-testing can enhance resilience across the financial system. This is consistent with the guiding principles of the Network for Greening the Financial System and aligns with global efforts to integrate biodiversity into financial decision-making. Frameworks developed through the NGFS already provide a foundation for incorporating nature-related risks; these can be expanded to include ocean-specific metrics and ecosystem tipping points.

Ocean-related risks can also affect price stability and should therefore be considered in monetary policy. Addressing them presents an opportunity for central banks to better align policy with transition goals while reducing risks to the financial system.

Monetary policy can help channel capital towards ocean-positive investments. Through green and blue refinancing frameworks, central banks could lower the cost of capital by accepting high-quality ocean-positive assets – such as sustainable fisheries, offshore renewable energy or coastal restoration projects – as collateral. Green finance has already proven effective in driving clean energy investment. Applying similar tools to the ocean economy could deliver comparable benefits.

Each year, an estimated $35bn in global subsidies continues to support overfishing, while fossil fuel subsidies distort energy markets and accelerate ocean warming and acidification. Fiscal and public-finance institutions can remove these persistent market distortions. Harmful subsidies – including those supporting fossil fuels and industrial overfishing – continue to drive ocean degradation. Redirecting these funds towards building coastal resilience, including in blue carbon ecosystems, sustainable seafood and coastal development, green/blue energy transition and nature-based solutions would strengthen both ecological and economic stability.

The transition to a sustainable blue economy is not a niche environmental area – it is a core requirement for long-term financial stability. To that end, the development of a blue taxonomy – in line with the EU’s green taxonomy – can provide a clear, credible framework for identifying sustainable ocean-related investments.

Ultimately, achieving a sustainable blue economy demands that the financial system internalises the true value of ocean ecosystems. Monetary and financial regulation policies that properly price risk, reward ecosystem restoration and penalise ocean degradation are essential to closing the gap between what our planet and people need and how markets currently behave. A healthy ocean – and the goods and services it provides – is a vital macroeconomic asset that underpins global prosperity.

Financial regulators and monetary authorities already have powerful tools with which to integrate and manage ocean-related risks and to ensure that the financial system is well aligned with the protection and restoration of ocean ecosystems.

The question is no longer whether the financial system should act, but how quickly it can integrate ocean stewardship into its mandate. The health of the global economy depends on the health of the ocean. The financial system must now rise to meet this reality.

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Sustainability Is Now a National Security Necessity *

By JORDAN NANN *

The intersection of defence and energy sovereignty

In the face of geopolitical and military conflict, sustainability has taken a backseat as world leaders prioritise defence spending and ensuring access to oil. However, prioritising defence over combatting climate change might be a short-sighted perspective.

As climate change wreaks havoc on the globe, wars become more dangerous and more likely. The US and Israel's war with Iran, and the Russia-Ukraine war before it, has demonstrated the precarity of relying on fossil fuels for energy supply. Sustainability has gone from being a nice-to-have to a matter of national security.

Iran and energy security

Iran's disruption of the Strait of Hormuz has demonstrated the inherent volatility of dependence on oil: 20% of global oil flows are reliant on a single trade route. Further strikes on fuel facilities by the US and Israel have only reinforced these concerns. Oil and liquified natural gas prices have fluctuated wildly owing to the tense state of peace-talks between the US and Iran. The oil market is set to lose at least 1bn barrels of crude and refined products due to the war.

Moving away from a reliance on oil and specific trade routes is necessary for protecting national security. John Kerry, former US secretary of state, said it clearly: the lesson to learn is how not be dependent on other countries for energy.

Countries are turning to alternative fossil fuels to meet energy demand, and coal has benefitted most from the first months of this war. Especially in Asia, which has arguably felt the greatest shocks due to high dependency on unstable oil and natural gas supply, coal has been booming, with many countries lifting restrictions on mining and use.

However, as a response to national security challenges, further emphasis on industrial pollutants will only exacerbate the very problems that governments are trying to solve. Further, the relationship between national security and sustainability is self-reinforcing: military action contributes to global temperature rises, creating a more unstable and globally tense geopolitical environment, prone to more extreme military action.

The intersection of climate and defence

Beyond energy security, sustainability may be the key to strong defence. In 2024, the UK published a report highlighting just how important sustainability and climate resilience is to military capability and defence. It found that: 'Failure to adopt changes in sustainable technology could leave our armed forces weaker, less agile, less resilient and less capable than our adversaries.'

Nato describes climate risk as a 'threat multiplier': physical changes to natural environments, like floods, droughts, temperature and geopolitical consequences of changing weather, increase economic and political instability in affected regions. For every one-degree Celsius rise in the global temperature, the world loses 12% in gross domestic product.

Further, climate shocks can lead to democratic decline and increased migration, which act as stress-multipliers in already unstable regions. Climate-exacerbated shortages increase societal instability, and rural degradation and declining economic decline make radicalisation more likely. Antonio Guterres, United Nations secretary-general, put it plainly: 'Our addiction to fossil fuels is destabilising both the climate and energy security… Climate chaos is accelerating and delay is deadly.'

These challenges must be reckoned with by all industries, and defence especially. The longer-term climate changes and effects of increased environmental degradation must be considered in military planning. These include adequate risk assessment and sustainable infrastructure investment. An OMFIF roundtable on nature-related risk highlighted how these concerns translate not just to defence, but to the financial ecosystem broadly: through supply chain disruption, inflationary pressures, and insurance market stress and reduced insurability.

More to the story

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The intersection between climate change and geopolitics goes beyond the supply of oil and gas for energy. The blockade of the Strait of Hormuz is impacting shipments of aluminium, green hydrogen infrastructure, nickel, cobalt, sulphur and graphite, which are all critical for sustainable infrastructure development, as well as for industrial, farming and medical functions. This is having an outsized impact on emerging markets in particular, where countries like India are still heavily reliant on fossil fuels for power, transport and cooking.

However, there could be some positive consequences of the oil volatility. For many countries, the most recent episode of conflict in the Middle East has laid bare the need to switch to renewable sources of energy. Countries like China and India are turning to green hydrogen, while China's solar panel exports soared to a record high in March.

Trade disruption has also impacted the supply of petrochemicals for other critical resources, such as plastic production. Some manufacturers in countries that are heavily reliant on plastic for packaging, such as Japan and South Korea, are turning to eco-friendly paper products. While switching to paper over plastic might not be the long-term permanent solution to the worlds' climate problems, a resurgence in research and development to find solutions and heightened interest in sustainability is refreshing.

As governments push for greater defence spending, the challenges posed by climate change to defence capacities matches the challenges posed to sustainable investors. The impact of climate change is far-reaching and devastating, feeding back into geopolitical instability and creating an ever-greater threat to national security.

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Liquidity, Sentiment, And Global Spillover Across Financial Markets [*]

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1. Introduction

In recent years, turmoil across key financial markets has shocked the global system and generated significant contagion. Understanding the origins and drivers of global spillovers is therefore critical for investors, consumers, and policymakers. Classical asset pricing theories emphasize fundamental channels, while behavioral work highlights the role of sentiment and other irrational forces. However, few studies have simultaneously addressed the relationship between fundamentals, sentiment, and global spillovers. This study attempts to fill this gap. One strand of research stresses that investor behavior leads to contagion across markets. Da et al. (2024) specifically demonstrate that sentiment spillovers significantly enhance comovement among assets. Additionally, various psychological factors, such as confidence, risk aversion, panic, or herding, have been documented to contribute to market contagion (e.g., Lin et al., 1994; Dornbusch et al., 2000; Benhabib et al., 2016; Platonov, 2024).

Another strand of research suggests that liquidity and other fundamental linkages can drive financial spillovers. Brunnermeier and Pedersen (2009) theoretically document that funding liquidity and market liquidity are mutually reinforcing, leading to volatility and comovements across securities. Empirical studies further confirm that funding flows intensify commonality across markets due to correlated trading behaviors (Kamara et al., 2008; Karolyi et al., 2012). Moreover, economic linkages such as trade links, monetary policies, and macroeconomic similarities also foster financial comovements (see, e.g., Dornbusch et al., 2000; Kodres and Pritsker, 2002; Kiyotaki and Moore, 2002; Bekaert et al., 2009; Yang and Zhou, 2017; Yang et al., 2020).

First, we evaluate the heterogeneous roles of sentiment, liquidity, and other fundamental linkages in driving global spillovers across financial markets. Specifically, investor sentiment acts as a key driver of short-run spillovers, while it does not directly trigger long-term spillovers. This suggests that investor sentiment primarily accounts for the transmission of short-term information rapidly incorporated into asset prices. Interestingly, investor sentiment derived from newspapers significantly dominates that from social media in driving financial spillovers. This finding aligns with the theoretical predictions of Goldstein et al. (2024) which suggest that information from social media may reduce market efficiency by worsening the trading performance of investors who are already well-informed by qualified news sources.

In contrast, the transmission of long-term information is predominantly driven by liquidity. Specifically, capital flows, serving as a proxy for bilateral funding flows, substantially enhance transmissions across financial markets, both in the short and long term. Our results align with findings from Karolyi et al. (2012) and Bartram et al. (2015) which show that capital flows, primarily driven by institutional investors, contribute to increased funding liquidity and common ownership. Therefore, the related trading behaviors among global institutions significantly enhance market interconnectivity. Moreover, market liquidity markedly triggers both short- and long-term spillovers, with more liquid markets exerting substantial influence over less liquid ones. Meanwhile, our findings support Guidolin et al. (2019), who propose a flight-to-liquidity channel in shaping spillovers. Additionally, unconventional monetary policies, interest rate policies, and economic growth have been identified as triggers for long-term spillovers.

Next, we extend our understanding of how market sentiment interacts with macroeconomic policies and liquidity to affect global financial stability. Initially, there is an asymmetric interaction effect between capital flows and market liquidity, in the sense that capital flows intensify the impact of market liquidity on financial

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spillovers, while market liquidity does not reversely enhance the impact of capital flows. Our results are partially consistent with the theoretical predictions of Brunnermeier and Pedersen (2009), underscoring the critical role of capital flows in adjusting market liquidity and triggering global spillovers. Next, we find the pivotal influence of investor sentiment on the power of capital flows. Specifically, investor overoptimism directly escalates the effect of capital flows on short-term spillovers. Moreover, investor overoptimism markedly enhances the impact of unconventional monetary policies, which in turn stimulate cross-border capital flows. This interaction subsequently leads to pronounced financial spillovers across both short- and long-term durations. Consistent with the majority of asset pricing literature (e.g., Baker and Wurgler, 2006; Huang et al., 2015; Da et al., 2024), the direct impact of sentiment is transient. Our findings contribute to the literature by demonstrating that overoptimism can intensify policy responses, which in turn lead to long-term spillovers across financial markets.

Our study makes several contributions. First, we extend the literature on the determinants of risk spillovers across global financial markets. Existing studies typically examine in isolation the roles of investor sentiment (Baker et al., 2012; Da et al., 2024), market liquidity (Brunnermeier and Pedersen, 2009), and other fundamental linkages (Bekaert et al., 2009; Yang and Zhou, 2017; Yang et al., 2020) in propagating spillovers. Building on research that decomposes market volatility into short- and long-run components (e.g., Engle and Rangel, 2008; Adrian and Rosenberg, 2008; Bandi et al., 2021), we link the short- and long-run components of volatility spillovers to investor sentiment and fundamental linkages. We find that investor sentiment primarily drives short-run spillovers, whereas long-run spillovers are predominantly associated with liquidity and other fundamental linkages.

Second, we contribute to the literature by examining the joint role of investor sentiment and liquidity and their interaction in shaping cross-market financial contagion. Karolyi et al. (2012) show that investor sentiment significantly contributes to commonality in liquidity. Baker et al. (2012) find that investor sentiment drives return comovements across global markets, with capital flows serving as an important transmission channel. Picault et al. (2022) show that sentiment significantly shapes the market reaction and expectations regarding monetary policy. We further link the interaction between sentiment and liquidity to volatility spillovers across financial markets and find that investor sentiment significantly amplifies the effects of capital flows and monetary policy on volatility spillovers across global markets.

Third, we extend the traditional Diebold-Yilmaz (DY) variance-spillover framework by introducing a marginal spillover network, which quantifies the evolution of the spillover-network structure. Diebold and Yilmaz (2014) develop a variance-decomposition network that measures pairwise directional connectedness between markets. Building on this framework, a growing literature has extended the DY methodology, such as high-dimensional (Demirer et al., 2018), probability-domain (Greenwood-Nimmo and Tarassow, 2022), and frequency-domain DY frameworks (Baruník and Křehlík, 2018). However, while most research focuses on the level of spillovers, studies examining structural changes in financial networks are scarce. Such research helps to provide investors with early warnings of systemic risk. Following the methodologies proposed by Yang and Zhou (2017), we first estimate the time-varying volatility spillover networks using a recursive algorithm. The initial estimate serves as a Bayesian prior, and the subsequent estimates incorporate both the prior and updated information (Yang and Zhou, 2017). For each estimation, we incorporate an expanding sample following the sample period of the preceding estimation. This approach allows us to construct marginal spillover networks by calculating the differences in recursively estimated spillover networks between consecutive trading days, thereby capturing structural changes in spillover networks in response to newly updated information.

Finally, we further quantify frequency-specific structural changes in spillover networks by integrating the spectral decomposition method of Baruník and Křehlík (2018) with the marginal spillover network. Diebold and Yilmaz (2023) highlight that one of the limitations of the DY framework is that the underlying mechanisms and the information transmission behind the connectedness remain incompletely understood. Our approach helps dissect the structural changes in spillover networks in response to the newly updated information at different frequencies. We then link them to investor sentiment and fundamental linkages to comprehensively examine the heterogeneous drivers of spillovers across different frequencies.

This paper is organized as follows. Section 2 introduces the dataset utilized in our analysis; Section 3 details the empirical methodologies employed to examine global and marginal spillover networks; Section 4 discusses the empirical findings. Section 5 presents the robustness checks. Finally, Section 6 summarizes the conclusions and applications of this study.

2. Data and variables

2.1. Futures contracts sample

In this study, our analysis focuses on the nearby futures of stock and commodity markets. Futures prices are used because they are widely regarded as benchmark prices for spot transactions, particularly in the case of commodity futures. The data is collected from Bloomberg, covering daily futures price data from June 2006 to December 2020.

To ensure broad international coverage and an extensive sample period, we collect stock index futures data from 15 major industrialized countries. The stock index futures data include the US (S&P500 Index Futures), Canada (S&P TSX 60 Index Futures), Russia (RST Index Futures), the UK (FT100 Index Futures), Germany (DAX Index Futures), France (CAC 40 Index Futures), Italy (FT MIB Index Futures), Switzerland (SMI Index Futures), Spain (IBEX35 Index Futures), Japan (Nikkei 225 Index Futures), Korea (KOSPI 200 Futures), India (NIFTY 50 Futures), China (FTSE China A50 Index Futures), Brazil (BOVESPA Index Futures), and Australia (ASX 200 Index Futures).

Furthermore, considering the interaction of commodities with global stock markets (Frankel, 2014), we collect data on two of the most liquid and essential commodity futures: COMEX gold futures and WTI crude oil futures. Additionally, to capture the connections between currency, implied volatility indices, and international stocks (e.g., Dumas and Solnik, 1995; Chan et al., 2018; Kang et al., 2019), we have also collected data for the S&P500 volatility index futures and the US Dollar index futures.

Following Forbes and Rigobon (2002) and Yang and Zhou (2017), we compute the two-day rolling average of futures prices to control for the fact that futures markets of different countries do not operate during the same trading hours. Notably, as negative values were observed in oil futures prices, we calculated simple returns using the formula $r_t = (P_t/P_{t-1} - 1) \times 100$.

Table 1 presents the summary statistics for the daily futures return series. Most futures earn positive returns, except for Spanish, Italian, and WTI crude oil futures. As evident from the standard deviation, WTI crude oil futures exhibit the highest risk, with a standard deviation of 0.052, followed by VIX futures at 0.046, Russian stock futures at 0.020, and Chinese stock futures at 0.016. Most futures have negative skewness, except for the Chinese, US Dollar, and VIX futures. Notably, the skewness of WTI crude oil futures, at −24.830, is significantly more negative than that of other futures, indicating a heightened risk of extreme losses. Additionally, all futures returns demonstrate a fat-tailed distribution, as evidenced by kurtosis values significantly exceeding three. The Jarque-Bera test statistics for all futures returns are significant, suggesting that none of the returns follow a normal distribution. Furthermore, according to first-order autocorrelations (AR1), most futures returns exhibit strong serial correlation. The Augmented Dickey-Fuller test confirms that all futures returns are stationary.

Table 1
Summary statistics of futures returns.

Market	Abbreviation	Mean	Std.Dev	Skewness	Kurtosis	Jarque-Bera	AR1	ADF	Nobs
SP500 Index Futures	USA	0.043 %	0.009	−0.942	10.814	13,759.134***	0.4500	−14.086***	2699
SP TSX 60 Index Futures	CAN	0.020 %	0.009	−1.668	28.303	93,212.088***	0.4550	−14.066***	2699
BOVESPA Index Futures	BRA	0.052 %	0.014	−0.588	9.846	11,227.373***	0.4780	−12.782***	2699
RTS INDEX Futures	RUS	0.015 %	0.020	−1.074	27.872	90,451.119***	0.4620	−13.170***	2699
FT100 Futures	GBR	0.008 %	0.010	−0.752	10.575	12,957.274***	0.4640	−14.497***	2699
KOSPI 200 Futures	KOR	0.036 %	0.011	−0.025	9.870	10,781.883***	0.4770	−14.719***	2699
NIFTY 50 Futures	IND	0.058 %	0.012	−0.307	8.553	8215.978***	0.5090	−13.532***	2699
DAX Futures	DEU	0.038 %	0.012	−0.737	7.614	6978.825***	0.4960	−14.449***	2699
CAC 40 Futures	FRA	0.009 %	0.011	−0.729	8.008	7702.791***	0.4800	−14.467***	2699
FT MIB Futures	ITA	−0.012 %	0.013	−0.978	9.738	11,408.165***	0.4920	−14.029***	2699
SMI Index Futures	CHE	0.017 %	0.009	−0.780	8.817	9349.392***	0.4570	−14.436***	2699
N225 Futures	JPN	0.027 %	0.012	−0.763	9.453	10,429.454***	0.4630	−14.112***	2699
IBEX35 Index Futures	ESP	−0.008 %	0.013	−0.595	7.910	7349.812***	0.4920	−14.358***	2699
FTSE CHINA A50 Index Futures	CHN	0.057 %	0.016	1.825	25.913	77,090.155***	0.5150	−12.301***	2699
ASX 200 Futures	AUS	0.014 %	0.009	−0.458	7.203	6085.573***	0.4630	−14.036***	2699
WTI Crude Oil Futures	WTI	−0.078 %	0.052	−24.830	843.490	83,641,899.027***	−0.1530	−15.312***	2699
COMEX Gold Future	GOL	0.045 %	0.009	−0.009	5.808	3745.103***	0.5090	−14.544***	2699
Dollar Index Futures	DX	0.003 %	0.004	0.432	4.106	2043.146***	0.4950	−14.804***	2699
S&P 500 VIX Short Term Futures	VIX	0.124 %	0.046	1.921	20.749	48,822.119***	0.4240	−14.531***	2699

Note: This table summarizes the daily returns of index futures, including statistical metrics such as the mean, standard deviation (Std.Dev), skewness, kurtosis, the first-order autocorrelation (AR1), the Jarque-Bera test statistics, and the Augmented Dickey-Fuller test statistics (ADF). "*", "**" and "***" denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels, respectively.

2.2. Sentiment, liquidity, and other fundamental variables

Utilizing the aforementioned futures returns, we analyze the interconnections among global financial markets. Subsequently, we link the global spillovers to investor sentiment, liquidity, and other fundamental factors to elucidate the underlying mechanisms. This section details the sentiment and fundamental data employed in our analysis.

The sentiment data in this study is collected from the Thomson Reuters MarketPsych Indices (TRMIs) dataset. TRMI is an advanced linguistic index that analyzes news and social media in real-time using natural language processing techniques to convert the volume and variety of professional news and online information into manageable score series. Powered by a complex grammar framework that includes traits specific to different text sources, MarketPsych's textual analytics boast customized lexicons, superior disambiguation, and optimized grammatical structures.

TRMI offers superior source coverage compared to other datasets commonly used in the academic community, as highlighted by Audrino and Tetereva (2019). It has also been employed as a proxy for investor sentiment in finance research, as documented by Michaelides et al. (2015, 2019). TRMI incorporates two content categories: news and social media. TRMI covers more than 2000 news sources, including leading professional financial news presses such as The Wall Street Journal, The Financial Times, and The New York Times, as well as other less influential news collected by Thomson Reuters News Feed Direct, such as Factiva News and Google News. TRMI also crawls and scrapes the top 30% of over two million blogs, stock message boards, and social media sites for daily estimations, including StockTwits, Yahoo! Finance, and SeekingAlpha.

The TRMI scoring algorithm extends the dictionary method (Loughran and McDonald, 2011). Specifically, the algorithm starts with identifying entity characteristics (e.g., the word "US" in the example sentence "Analysts expect a significant growth in the US stock market next quarter" will be identified as the associated country ticker "US"). MarketPsych searches for keywords associated with an entity of interest. These keywords are then mapped to various asset-related topic variables (e.g., the word "stock" in the above example will be mapped to the topic "asset price"). Next, the algorithm searches for positive and negative words associated with the keywords (e.g., the word "growth" in the above example is identified as an up-word with a positive value based on the emotional intensity, whereas a down-word is assigned a negative value). A numerical value for tense, proximity, and other multipliers is assigned to each topic variable (e.g., the word "significant" is identified as a multiplier whose value depends on the intensity). A numerical score related to this sentence is calculated by summing the product of emotional keywords and their corresponding modifier words. Scores of variables and sentences referring to the same topic are aggregated into a topic sentiment score. There are a total of 48 topic subindices, reflecting media commentary on political, economic, financial, societal, and environmental aspects. An overall sentiment index is then computed by aggregating these subindices using a weighted average method, with weights assigned according to the number of references for each topic. The overall sentiment index is scaled from -1 to 1. Negative (positive) values represent pessimism (optimism), with a higher absolute value of the score indicating a higher degree of sentiment.

The investor sentiment measures utilized in this study are the overall sentiment indices of 15 countries derived from combined sources of news and social media. After matching with the futures return sample and estimated spillover indices, the final sample period spans from March 31, 2008, to December 31, 2020. Table 2 reports summary statistics for overall sentiment indices. The overall sentiments are negative for most markets on average. The standard deviation of sentiment scores varies, ranging from 0.033 in the Australian market to 0.080 in the Brazilian market. The skewness of the sentiment indices is consistently negative. Significant Jarque-Bera test statistics indicate that the sentiment distributions do not follow a normal distribution. Moreover, the first-order autocorrelations (AR1) reveal strong serial correlations in the sentiment indices. The Augmented Dickey-Fuller (ADF) test confirms that the sentiment measures are stationary.

Table 2
Summary statistics of MarketPsych sentiment indices.

Market	Mean	Std.Dev	Skewness	Kurtosis	Jarque-Bera	AR1	ADF	Nobs
USA	−0.070	0.035	0.137	2.631	40.966***	0.776	−5.266***	4663
CAN	−0.036	0.050	−0.198	2.787	39.282***	0.662	−6.721***	4663
BRA	−0.070	0.080	−0.194	2.985	29.146***	0.657	−8.416***	4663
RUS	−0.136	0.052	0.110	3.034	9.620***	0.726	−8.282***	4663
GBR	−0.069	0.036	−0.159	3.305	37.779***	0.697	−6.682***	4663
KOR	−0.091	0.076	−0.011	3.288	16.187***	0.483	−8.552***	4663
IND	−0.093	0.032	0.395	4.915	833.905***	0.627	−9.795***	4663
DEU	−0.061	0.049	−0.050	3.668	88.594***	0.548	−9.098***	4663
FRA	−0.065	0.049	−0.219	3.294	54.158***	0.593	−9.649***	4663
ITA	−0.060	0.063	−0.447	4.416	544.793***	0.643	−8.428***	4663
CHE	−0.038	0.063	−0.118	3.657	94.628***	0.398	−11.046***	4663
JPN	−0.068	0.051	−0.420	3.824	268.788***	0.592	−8.022***	4663
ESP	−0.059	0.068	−0.119	3.834	146.181***	0.548	−9.456***	4663
CHN	−0.045	0.048	−0.535	3.885	374.279***	0.704	−7.522***	4663
AUS	−0.084	0.033	−0.733	5.345	1486.362***	0.573	−8.685***	4663

Note: The table reports summary statistics for overall sentiment indices sourced from the combined content of news and social media, including statistical metrics such as the mean, standard deviation (Std.Dev), skewness, kurtosis, the first-order autocorrelation (AR1), the Jarque-Bera test statistics, and the Augmented Dickey-Fuller test statistics(ADF). "*", "**" and "***" denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels, respectively.

Another focus of our research is the role of liquidity and other fundamental linkages in driving spillovers across global financial markets. Regarding liquidity factors, our first focus is capital flows, characterized by bilateral portfolio investment flows. Capital flows are primarily driven by institutional investors who play a critical role in providing funding liquidity, as documented by Karolyi et al. (2012). We collect bidirectional portfolio investment flows across economies from the Coordinated Portfolio Investment Survey (CPIS) of the International Monetary Fund (IMF). We then standardize the bilateral capital flow by calculating the share of the flow from a source economy j to a recipient economy i (denoted as SPI_{i-j}) over the total inflows of the recipient economy i. The standardized capital flow is represented as $PI_{i-j} = SPI_{i-j}/(\sum_i SPI_{i-j})$, which quantifies the importance of bilateral portfolio investment flows to the destination countries. Second, motivated by the interplay between funding liquidity and market liquidity, as theoretically documented by Brunnermeier and Pedersen (2009), our analysis extends to market liquidity. We account for differences in market liquidity (LIQ) between markets, which is measured as the negative value of the illiquidity measures proposed by Amihud (2002). Specifically, we calculate this monthly illiquidity measure as the average ratio of daily return to trading volume within a month.

Regarding economic linkages, our third focus is on bilateral trade. We gather bidirectional exports and imports data among areas and countries from the Direction of Trade Statistics (DOTS) dataset provided by the IMF. Similarly, employing the same standardized algorithm used for capital flows, we compute the measures of TRA_{i-j} to quantify the relative importance of trade linkages to the recipient economies. In addition, we also examine other economic similarities by calculating the differences in GDP, short-term interest rates (3-month treasury rate), and inflation (CPI growth) between economies.

In addition, unconventional monetary policies, including quantitative easing and tapering, are documented as significant channels for financial contagion (Dornbusch et al., 2000). In the context of a crisis, these policies can effectively adjust market liquidity, control inflation, and enhance export competitiveness. However, they may also exert pressure on other countries, potentially prompting those nations to adopt similar strategies to mitigate adverse impacts (Rajan, 2015). Yang and Zhou (2017), Yang et al. (2020) emphasize the significant roles that US quantitative easing and tightening play in escalating global systemic risks, respectively. Motivated by the approach of Yang and Zhou (2017), we use the monthly increments of security purchases as a proxy to gauge the scale of unconventional monetary policies. To quantitatively assess the degree of similarity between the unconventional monetary policies of two economies, we introduce a metric, UMP_{i-j}, by calculating the difference in the extent of unconventional monetary policies between economies j and i. The aforementioned macroeconomic variables are collected from the CEIC database.

3. Methodologies

First, we recursively estimate the generalized forecast error variance decomposition to construct time-varying weighted directed spillover networks. We then introduce the marginal volatility spillover networks by considering the differences in recursively estimated spillover networks between subsequent trading days. These networks trace adjustments in global volatility spillovers in response to newly updated innovations. Furthermore, using the Fourier transform technique, we decompose global volatility spillover networks into short- and long-term components. Finally, we develop hypotheses and models that explore determinants of volatility contagion across various frequency domains.

3.1. Global spillover networks

We construct a global spillover network to capture interdependence across 19 futures return series using the generalized forecast error variance decomposition (GFEVD) of Diebold and Yilmaz (2014, 2023). Specifically, we estimate a non-orthogonalized vector autoregression (VAR) and obtain its infinite moving-average representation. From this representation, we compute the H-step-ahead impulse response coefficient matrices $\{A_h, h = 0,1, \ldots, H-1\}$.

The H-step-ahead generalized forecasting error variance decomposition (Diebold and Yilmaz, 2014, 2023) is presented as follows:

$$\theta_{i-j}^{H} = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} e_i' A_h \Sigma A_h' e_i}, i, j \in \Omega, (1)$$

where Σ represents the covariance matrix of the error term of VAR, σ_{jj} denotes the standard deviation of the error term for the return of market j, and e_i is a selection vector, with its i-th element set to one and all others to zero. Ω represents the sample set that includes the 19 futures returns. This ratio quantifies the percentage of market i's (spillover receiver) H-step-ahead error variations that can be explained by the shock from market j (spillover sender).

Given that the sum of cross-asset contribution shares does not equal one, we normalize each entry of the variance decomposition matrix by its row sum, as follows:

$$\Theta_{i-j}^{H} = \frac{\theta_{i-j}^{H}}{\sum_{j=1}^{H} \theta_{i-j}^{H}}. (2)$$

Considering that the variance decomposition, as presented in Eq. (2), is not additive or comparable due to significant differences in historical volatility among spillover receivers, we extend the methodology of Diebold and Yilmaz (2014) by incorporating a weighting scheme that accounts for the receivers' historical volatility. The specifics of this scheme are detailed in Eq. (3):

$$S_{i-j}^{H} = \omega_i \Theta_{i-j}^{H}, (3)$$

where ω_i is the historical volatility of market i. The pairwise index S_{i-j}^{H} is a measure of the intensity of volatility spillovers from market j to market i. The collection of bilateral connectedness measures $\{S_{i-j}^{H}, i, j \in \Omega\}$ defines a weighted, directed network, namely the global spillover network.

Next, based on the structure of the global spillover network, we proceed to construct several indicators to measure the spillover intensities at the market and system levels. Initially, we define the in-strength sequence $TS_{in,i-s}^{H}$ and the out-strength sequence $TS_{out,s-i}^{H}$ for all $i \in \Omega$ as follows:

$$TS_{in,i-s}^{H} = \sum_{j} S_{i-j}^{H}, TS_{out,s-i}^{H} = \sum_{j} S_{j-i}^{H}, \text{for all } i \in \Omega \text{ and } i \neq j, (4)$$

where the in-strength sequence aggregates the spillovers from all other markets to a specific market, and the out-strength sequence sums the spillovers sent by that specific market to all others. The net total spillover (NTS) is defined as the difference between the out-strength and in-strength sequences, as follows:

$$NTS_{i}^{H} = \sum_{j} S_{j-i}^{H} - \sum_{j} S_{i-j}^{H} = TS_{out,s-i}^{H} - TS_{in,i-s}^{H}, \text{for all } i \in \Omega, (5)$$

where NTS_i^H identifies the nature of the market and determines whether it is a net receiver or transmitter, illustrating its net influence within the financial system. The gross total spillover (GTS) is defined in Eq. (6), which is analogous to a country's gross trade volume.

$$GTS_{i}^{H} = TS_{out,s-i}^{H} + TS_{in,i-s}^{H}, \text{for all } i \in \Omega. (6)$$

The system-wide total spillover (STS) is defined as the summation of all off-diagonal elements within the spillover network, as specified below. This index quantifies the intensity of transmissions across all markets and assets in the system.

$$STS^H = \sum_i TS^H_{out,s-i} = \sum_i TS^H_{in,i-s} = \sum_i \sum_j S^H_{i-j} \quad (7)$$

3.2. Marginal global spillover networks

To examine the structural dynamics of volatility spillover networks, we employ a recursive estimation process to calculate the time series variance decomposition. For each estimation, an expanding sample is incorporated after the previous sample period. Compared to the rolling window estimation method employed by Diebold and Yilmaz (2014, 2023), our approach of recursive estimation is justified by two primary considerations.

First, empirical studies have demonstrated that the conditional volatility of asset prices exhibits long memory or long-run persistence (Bollerslev and Mikkelsen, 1996; Breidt et al., 1998). This characteristic suggests that recursive estimation, which inherently accounts for historical volatility patterns, is particularly suitable for modeling volatility dynamics over time. Second, as documented by Yang and Zhou (2017), the outcome of recursive estimation is a sample of spillover estimates, which are updated in a Bayesian manner. The initial estimate serves as a Bayesian prior, and the subsequent estimates incorporate both the prior and updated information, leading to more accurate and robust estimates of spillovers over time.

Based on the above understanding of the recursive process, we define the marginal spillover intensity (MS) by calculating the differences in recursively estimated spillover networks between adjacent trading days, which appropriately reflect the dynamic changes in spillover networks in response to incremental updates in their recursive information sets. The formula is given as follows:

$$MS^H_{i,j-i} = S^H_{i,j-i} - S^H_{i-1,j-i}. \quad (8)$$

$MS^H_{i,j-i}$ measures the marginal effect of newly updated information at time t on the spillover intensity from market j to i. A positive (negative) $MS^H_{i,j-i}$ suggests that the spillover intensity from market j to i increases (decreases) when an innovation (event) occurs at time t. The collection of bilateral marginal spillover intensities $\{MS^H_{i,j-i}, i, j \in \Omega\}$ is defined as the marginal spillover network.

Similarly, we construct several market-level indicators to measure the marginal changes in market spillovers. The marginal in-strength sequence ($MTS^H_{in,i,j}$) quantifies the marginal changes in total spillovers received by market i from others, and the marginal out-strength sequence ($MTS^H_{out,i,j}$) quantifies the marginal changes in total spillovers sent by market i to others. These are defined as follows:

$$MTS^H_{in,i-s} = \sum_j MS^H_{i,j-i}, \; MTS^H_{out,s-i} = \sum_j MS^H_{i,j-i}, \text{ for all } i \in \Omega \text{ and } i \neq j, \quad (9)$$

and the market-wise marginal net total spillover ($MNTS$) is defined as follows, measuring the marginal changes in the net influence of market i on the financial system:

$$MNTS^H_{i,j} = MTS^H_{out,s-i} - MTS^H_{in,i-s}, \text{ for all } i \in \Omega. \quad (10)$$

3.3. Dynamics of spillover networks in frequency domains

Following the methodology outlined by Barunik and Krehlik (2018), the generalized causation spectrum over frequencies $\omega \in (-\pi, \pi)$ is defined as follows:

$$(\xi(\omega))_{j,k} = \frac{\sigma_{kk}^{-1} |(A(e^{-i\omega})\Sigma)_{j,k}|^2}{(A(e^{-i\omega})\Sigma A'(e^{+i\omega}))_{j,j}}, \text{ for } j, k \in \Omega (11)$$

where $(\xi(\omega))_{j,k}$ represents the portion of the spectrum of market j at a given frequency ω due to shocks from market k. i is the imaginary unit, defined such that $i^2 = -1$. The term $A(e^{-i\omega})$ represents the Fourier transform of the impulse response A_h.

Considering a specific frequency interval $d \in (a, b)$, where $a, b \in (-\pi, \pi)$ and $a < b$, we calculate the generalized forecasting error variance decomposition from market k to j in the frequency domain d as a weighted average of $(\xi(\omega))_{j,k}$, weighted by the frequency share of the variance of market j, denoted by $\Gamma_j(\omega)$. The weighting function is defined as follows:

$$\Gamma_j(\omega) = \frac{(A(e^{-i\omega})\Sigma A'(e^{+i\omega}))_{j,j}}{\frac{1}{2\pi}\int_{-\pi}^{\pi} (A(e^{-i\omega})\Sigma A'(e^{+i\omega}))_{j,j} d\omega} (12)$$

The following proposition establishes the spectral representation of the variance decomposition from market k to j, and it is central to the development of the connectedness measures in the frequency domain.

$$(\theta_d)_{j-k} = \frac{1}{2\pi}\int_a^b \Gamma_j(\omega)(\xi(\omega))_{j,k} d\omega \text{, for } j,k \in \Omega, (13)$$

As suggested by Barunik and Krehlik (2018), we decompose the total connectedness based on frequency bands of short-term (1-22 days, within a month) and long-term (above 22 days, more than one month) periods. This decomposition allows us to analyze the transmission of shocks across various horizons. Specifically, the high-frequency component elucidates the short-term cyclical behavior of spillovers, while the low-frequency component underscores the intensity of more prolonged transmission effects.

Similarly, by employing Eqs. (3)-(7) and Eqs. (8)-(10), we further examine both frequency spillover networks and marginal frequency spillover networks, and subsequently compute the corresponding frequency market- and system-wise spillover indices.

3.4. Frameworks and models on determinants of global spillovers

In this subsection, we provide an overview of the theoretical framework pertaining to the determinants of financial spillovers and develop corresponding hypotheses. Subsequently, we conduct our empirical analysis to test these hypotheses.

Following the principles of classic behavioral finance, we integrate the influences of investor sentiment and fundamental factors to evaluate their combined effect on spillovers. Subsequently, building on the theory of heterogeneous information in asset prices across different horizons, we develop a unified framework to explore how investor sentiment, liquidity, and other fundamental factors are interconnected with spillovers at different frequencies.

First, the traditional theory posits that price comovement reflects fundamental value comovement. In a frictionless economy with rational investors, price equals fundamental value, and so comovement in prices must be due to comovement in fundamentals (Barberis et al., 2005). Brunnermeier and Pedersen (2009) theoretically emphasize the important role of liquidity factors in triggering volatility and comovements across securities. When the market declines, financial intermediaries are forced to decrease the supply of liquidity due to the decreased collateral values and increased margins, consequently leading to financial contagion. Bartram et al. (2015) further emphasize that cross-border capital flows lead to increased international ownership. Subsequently, the correlated trading behavior of international institutional investors significantly enhances the comovement among markets.

Second, behavioral finance enriches asset pricing by acknowledging that investor sentiment and fundamentals jointly influence asset prices. De Long et al. (1990) theoretically analyze the determinants of asset prices from two distinct perspectives: fundamental values and investor beliefs. Return movements cannot be adequately explained by fundamental valuation models. Investor sentiment refers to the general mood or attitude of investors toward market conditions or specific assets, detached from fundamentals (Baker and Wurgler, 2006, 2007). Barberis et al. (2005) theoretically prove that price comovement cannot be explained solely by changes in fundamental linkages, which are measured by cash-flow correlations, when considering the sentiment of noise traders. They further provide evidence supporting sentiment-based theories of price comovement. Da et al. (2024) argue that investor sentiment triggers noise trading among assets, leading to contemporaneous variations in asset returns.

Third, the literature demonstrates that asset prices and volatility are subject to shocks occurring at different frequencies and relates them to both fundamental-based and behavior-based explanations (Adrian and Rosenberg, 2008; Engle and Rangel, 2008; Bandi et al., 2021). Bandi et al. (2021) introduce a spectral factor model to capture fluctuations with cycles of varying lengths. Their findings suggest that market dynamics associated with longer cycles—specifically those exceeding one month—reflect price fundamental information, such as the size, value, investment, profitability, consumption, and other firm- and macro-level anomalies. Similarly, Engle and Rangel (2008) decompose aggregate volatility into high- and low-frequency components. They find that the low-frequency component, which captures slow-moving trends in the volatility process, is primarily influenced by macroeconomic and financial variables such as production growth, interest rates, and inflation. Adrian and Rosenberg (2008) decompose stock market volatility into short- and long-run components. They show that the short-run component captures market skewness risk, which is widely discussed as being related to investor sentiment (Dennis and Mayhew, 2002), while the long-run component is associated with business cycle risk.

Based on the determinants of short- and long-term components of price and volatility, we propose the following hypotheses that link the dynamics of volatility spillovers across various frequencies to investor sentiment and market fundamentals:

Hypothesis 1: Investor sentiment primarily drives short-run volatility spillovers across financial markets.

Hypothesis 2: Liquidity, along with other fundamental factors, predominantly influences long-run volatility spillovers.

To test our hypotheses, we regress the marginal spillover networks at various frequencies on lagged sentiment, liquidity, and other fundamental linkages, as specified below:

$$MS_{i\leftarrow j,f,t} = \beta_1 \times SENT_{i\leftarrow j,t-1} + \beta_2 \times PI_{i\leftarrow j,t-1} + \beta_3 \times LIQ_{i\leftarrow j,t-1} + \Gamma \times Fundamental_{i\leftarrow j,t-1} + \theta X_{i,j,t-1} + \gamma_t + \mu_{ij} + \epsilon_{ij,t}, (14)$$

where $MS_{i\leftarrow j,f}$ represents the pairwise marginal spillover intensity from market j to market i at frequency f. To ensure comparability among different frequency components, we standardize our main dependent variables by subtracting their respective means and scaling by their standard deviations. $SENT_{i\leftarrow j}$ quantifies the difference in investor sentiment between market j and market i, indicating the relative optimism of market j compared to market i. $PI_{i\leftarrow j}$ denotes the bilateral portfolio investment flows from market j to market i, scaled by the total capital inflows of market i. $LIQ_{i\leftarrow j}$ measures the disparity in market liquidity between market j and market i. $Fundamental_{i\leftarrow j,t}$ encompasses other fundamental linkages. Specifically, $UMP_{i\leftarrow j}$ measures the disparity in unconventional monetary policies between markets. $TRA_{i\leftarrow j}$ represents the bilateral trade from market j to market i, scaled by the total imports of market i. Additionally, to account for other economic similarities, we consider differences in GDP, short-term interest rates (denoted as INT), and CPI growth (denoted as $Inflation$) between economies.

Turning to the control variables $X_{i,j}$, we incorporate differences in skewness ($SKEW$) and returns (RET) between markets to account for varying market dynamics. To mitigate potential omitted variable bias stemming from unobserved linkages, country-specific characteristics, and time-varying common shocks, we incorporate a comprehensive set of fixed effects, including pairwise market-by-market (μ_{ij}) and time-specific (γ_t) fixed effects.

Based on our specification, Hypothesis 1 posits that the coefficient of investor sentiment, β_1, on short-term spillovers should be more statistically significant than that on long-term spillovers. Hypothesis 2 suggests that the coefficients of capital flows (β_2), market liquidity (β_3), or some other fundamental factors (some elements of Γ) should be more statistically significant on long-term spillovers than those of investor sentiment.

4. Empirical results

In this section, we discuss our empirical findings. Section 4.1 investigates the structure of the global spillover network. Section 4.2 shifts to analyzing market-specific spillover indices, which elucidate the roles of particular markets in influencing global financial spillovers. This section highlights distinct characteristics of volatility spillovers across various frequency ranges. In Section 4.3, we assess the general trends of dynamic changes in system-wide spillovers. We use the April 2020 event, where WTI futures prices fell below zero, as a case study to investigate the structural changes in global spillover networks induced by this shock. Finally, Section 4.4 investigates the determinants influencing spillovers across global financial markets.

4.1. Structure of the global spillover network

In this section, we construct the global spillover network by analyzing returns from 19 futures markets throughout the entire sample period, using the generalized variance decomposition method detailed in Eqs. (1) to (3). The results are displayed in Table 3, where the ij-th element, $\{S_{i\leftarrow j}\}$, denotes the intensity of spillover from market j to market i.

This network unveils a pronounced asymmetric structure in the volatility spillovers among global financial markets, showing significant directional disparities in how shocks or information are transmitted across different markets. Such asymmetry not only elucidates the inherent complexities within the financial system but also underscores the differential impacts that individual markets may exert on global financial stability.

First, as evidenced by the diagonal elements of the spillover matrix, the magnitude of each diagonal entry is consistently larger than those of the other elements within the same row. This indicates that the volatility of financial markets is primarily driven by shocks and information originating from their own markets. Aside from local self-effects, the US stock market emerges as the predominant transmitter of volatility to other markets. As shown in the column labeled "US" of Table 3, the volatility dynamics of the Canadian, Brazilian, Korean, Indian, Japanese, Australian, and VIX markets are substantially influenced by the US stock market, as the volatility spillovers from the US to these markets are systematically larger than those originating from other foreign markets.

Second, the evidence shows that the markets of Western European countries—namely the UK, Germany, France, Italy, and Switzerland—are closely interconnected, as evidenced by the fact that volatility spillovers among these Western European markets are systematically larger than those originating from markets of other regions. Such pronounced interconnections underscore the economic and financial integration prevalent within Western Europe.

Third, the VIX and WTI markets are identified as the primary recipients of shocks from most markets, indicating that the crude oil and VIX are intricately linked to the economic and financial fluctuations of economies. Particularly, the VIX futures market is predominantly influenced by the US stock market, with a measurable impact of 2.297 basis points. The WTI futures market is primarily affected by the Russian market, with a significant influence quantified at 0.688 basis points.

Table 3
Global spillover network across financial markets.

	USA	CAN	BRA	RUS	GBR	KOR	IND	DEU	FRA	ITA	CHE	JPN	ESP	CHN	AUS	WTI	GOL	DX	VIX
USA	0.138	0.085	0.061	0.042	0.072	0.029	0.024	0.074	0.071	0.058	0.056	0.025	0.056	0.006	0.028	0.002	0.002	0.013	0.060
CAN	0.097	0.140	0.067	0.049	0.070	0.031	0.024	0.064	0.063	0.054	0.047	0.029	0.049	0.007	0.033	0.003	0.006	0.014	0.041
BRA	0.176	0.176	0.384	0.119	0.137	0.074	0.063	0.129	0.133	0.112	0.092	0.051	0.114	0.029	0.065	0.004	0.016	0.047	0.077
RUS	0.294	0.312	0.288	0.808	0.295	0.151	0.164	0.293	0.283	0.242	0.173	0.115	0.228	0.049	0.125	0.023	0.046	0.118	0.156
GBR	0.080	0.065	0.050	0.043	0.118	0.032	0.026	0.087	0.092	0.073	0.074	0.031	0.071	0.006	0.033	0.001	0.002	0.006	0.043
KOR	0.083	0.068	0.065	0.061	0.079	0.197	0.059	0.083	0.081	0.061	0.054	0.066	0.061	0.018	0.062	0.002	0.003	0.016	0.045
IND	0.094	0.073	0.075	0.065	0.086	0.085	0.296	0.089	0.085	0.072	0.060	0.050	0.075	0.019	0.058	0.001	0.008	0.016	0.045
DEU	0.109	0.078	0.062	0.062	0.121	0.045	0.038	0.176	0.146	0.123	0.100	0.042	0.114	0.009	0.038	0.002	0.001	0.009	0.059
FRA	0.104	0.079	0.063	0.057	0.123	0.041	0.034	0.137	0.160	0.126	0.098	0.042	0.123	0.009	0.040	0.002	0.001	0.009	0.060
ITA	0.124	0.100	0.081	0.072	0.146	0.047	0.045	0.172	0.188	0.247	0.122	0.050	0.188	0.010	0.050	0.003	0.000	0.016	0.074
CHE	0.074	0.052	0.038	0.029	0.083	0.023	0.020	0.080	0.081	0.068	0.120	0.027	0.064	0.004	0.028	0.001	0.001	0.001	0.038
JPN	0.119	0.089	0.068	0.068	0.103	0.092	0.052	0.118	0.114	0.093	0.087	0.227	0.088	0.018	0.073	0.003	0.000	0.005	0.070
ESP	0.112	0.085	0.076	0.062	0.131	0.041	0.042	0.149	0.171	0.175	0.111	0.045	0.231	0.008	0.045	0.003	0.001	0.015	0.066
CHN	0.103	0.090	0.130	0.084	0.096	0.122	0.092	0.110	0.096	0.089	0.074	0.080	0.079	1.111	0.082	0.001	0.008	0.017	0.069
AUS	0.075	0.067	0.048	0.037	0.066	0.046	0.032	0.060	0.062	0.051	0.050	0.041	0.052	0.009	0.123	0.003	0.002	0.007	0.042
WTI	0.407	0.491	0.261	0.688	0.440	0.126	0.191	0.355	0.372	0.365	0.158	0.167	0.325	0.037	0.225	22.029	0.230	0.296	0.300
GOL	0.002	0.019	0.017	0.015	0.003	0.003	0.004	0.002	0.001	0.001	0.003	0.001	0.001	0.002	0.000	0.002	0.665	0.120	0.002
DX	0.007	0.006	0.008	0.009	0.003	0.004	0.004	0.004	0.004	0.005	0.001	0.002	0.005	0.001	0.003	0.001	0.013	0.082	0.002
VIX	2.297	1.333	1.021	0.743	1.421	0.479	0.394	1.419	1.540	1.344	1.136	0.490	1.257	0.118	0.466	0.060	0.021	0.159	5.452

Note: This table presents the spillover matrix among global financial markets, as estimated using the entire sample dataset. Each ij-th element, denoted as $\{S_{i \leftarrow j}\}$, quantifies the pairwise spillover intensity from market j to market i. The unit for numerical values is the basis points.

4.2. Market-wise spillover indices and their frequency-domain components

In previous studies, we have estimated the pairwise spillover intensities between markets, showing an asymmetric spillover matrix. In this section, following the methodology outlined by Yang and Zhou (2017), we recursively estimate the dynamics of the spillover networks. We specifically focus on the market-wise spillover indices, as defined by Eqs. (4)-(6), to elucidate the role of specific markets within the global financial system.

Table 4 summarizes the average time-series market-wise spillover indices. The column labeled "TS_{in}" corresponds to the in-strength, as defined in Eq. (4), which quantifies the cumulative spillovers received by the market in the corresponding row from all other markets. The column labeled "TS_{out}" corresponds to the out-strength, also specified in Eq. (4), representing the total spillovers transmitted by the market in the corresponding row to all other markets. The column labeled "NTS", calculated as the difference between out-strength and in-strength (Eq. 5), represents the net total spillover. The column labeled "GT", calculated as the summation of out-strength and in-strength (Eq. 6), represents the gross total spillover.

First, as shown in the column labeled NTS, the US and UK stock markets emerge as the top two largest net senders of volatility, with net spillover intensities of 3.276 and 2.531 basis points, respectively. This finding highlights the critical role of the US and UK stock markets in transmitting volatility, predominantly exerting influence rather than being influenced by other markets. In contrast, markets such as Japan, gold, India, China, WTI, Russia, and VIX futures are net receivers of volatility spillovers, with values ranging from -0.036 basis points in the Japanese stock futures market to -12.640 basis points in the VIX futures market. This indicates that these markets are predominantly influenced by external markets rather than influencing others.

Additionally, as indicated in the column labeled GTS, there is a notable contrast between the rankings of gross total spillovers and net total spillovers. The VIX and Russian futures markets are ranked as the top two for gross total spillovers, primarily because they receive the most inbound volatility from other markets. Conversely, the gold futures market, with 0.765 basis points, and the US Dollar, with 1.355 basis points, are ranked as the bottom two for gross total spillovers. This observation suggests that these two markets are relatively independent of others and, therefore, are considered safe-haven assets.

Finally, following Eq. (7), we calculate the system-wide total spillover intensity by the summation of the in-strength or the out-strength sequences of all markets. The system-wide total spillover intensity is quantified at 43.049 basis points. The average spillover in-strength or out-strength is approximately 2.266 basis points. As indicated in the column labeled TS_{out}, the spillovers originating from the US, the UK, Canada, France, Germany, Switzerland, Italy, Spain, and Brazil markets significantly exceed this average. Conversely, as shown in the column labeled TS_{in}, the spillovers directed to these countries generally remain below the average. This pattern underscores the pivotal role of these markets in driving financial spillovers.

Next, we are interested in the heterogeneous patterns of spillovers across various frequencies. We estimate frequency-domain spillover networks using Eq. (13) and subsequently calculate the market-wise frequency spillover indices using Eqs. (4)-(6). Panels A and B of Table 5 report the time-series average of the market-wise frequency spillover indices for the short (high-frequency component with the cycle of 1-22 days) and long terms (low-frequency component with the cycle of above 22 days), respectively. The markets are ranked according to their net total spillovers.

The rankings across different frequencies display consistent patterns for most markets. The US stock market consistently emerges as the largest net exporter in both high- and low-frequency components, whereas the VIX futures market remains the largest net receiver across all frequencies.

More importantly, by comparing the magnitude of indices between Tables 4 and 5, we document that shocks are transmitted with varying strengths at different frequencies. The high-frequency components of spillovers, with net total spillovers ranging from 3.003 to −11.666, constitute the majority, accounting for over 90 %, of the overall net total spillovers (ranging from 3.276 to−12.640). The low-frequency spillovers, ranging from 0.273 to −0.975, account for the remaining 10 % of total spillovers. These results indicate that most shocks generating uncertainty in the system propagate rapidly and typically persist for no more than one month. The significant differences between the short-term and long-term components suggest a heterogeneous mechanism behind these spillovers, a topic we will explore further in Section 4.4.

Table 4

Market-wise spillover indices.

Rank	Market		NTS	TS_{out}	TS_{in}	GTS
1	USA	Net Senders	3.276	4.281	1.005	5.287
2	GBR		2.531	3.573	1.042	4.615
3	CAN		2.224	3.285	1.061	4.346
4	FRA		2.163	3.521	1.358	4.879
5	DEU		2.037	3.423	1.386	4.808
6	CHE		1.838	2.741	0.903	3.644
7	ITA		1.594	3.244	1.650	4.894
8	ESP		1.344	2.902	1.559	4.461
9	DX		1.098	1.227	0.129	1.355
10	BRA		1.071	3.126	2.055	5.181
11	AUS		0.785	1.802	1.017	2.819
12	KOR		0.282	1.675	1.393	3.068
13	JPN	Net Receivers	−0.036	1.655	1.691	3.346
14	GOL		−0.041	0.362	0.403	0.765
15	IND		−0.137	1.524	1.660	3.184
16	CHN		−1.997	0.339	2.336	2.675
17	WTI		−2.088	0.878	2.966	3.844
18	RUS		−3.302	2.037	5.339	7.377
19	VIX		−12.640	1.454	14.095	15.549

Note: This table summarizes the average time-series market-wise spillover indices and the ranking of net spillover indices from high to low. The column labeled "TS_{in}" corresponds to the in-strength, as defined in Eq. (4), which quantifies the cumulative spillovers received by the market of the corresponding row from all other markets. The column labeled "TS_{out}" corresponds to the out-strength, also specified in Eq. (4), representing the total spillovers transmitted by the market of the corresponding row to all other markets. The column labeled "NTS", calculated as the difference between out-strength and in-strength (Eq. 5), represents the net total spillover. The column labeled "GTS", calculated as the summation of out-strength and in-strength (Eq. 6), represents the gross total spillover.

Table 5
Market-wise spillover indices at different frequencies.

Panel A: high-frequency				Panel B: low-frequency			
Market (1)	*NTS* (2)	TS_{out} (3)	TS_{in} (4)	Market (5)	*NTS* (6)	TS_{out} (7)	TS_{in} (8)
USA	3.003	3.933	0.929	USA	0.273	0.349	0.076
GBR	2.325	3.285	0.960	CAN	0.220	0.293	0.073
CAN	2.003	2.991	0.988	GBR	0.206	0.288	0.082
FRA	1.988	3.241	1.253	DEU	0.181	0.292	0.110
DEU	1.855	3.131	1.275	FRA	0.176	0.280	0.105
CHE	1.690	2.513	0.823	CHE	0.148	0.228	0.080
ITA	1.493	2.998	1.505	BRA	0.124	0.278	0.154
ESP	1.242	2.674	1.431	ITA	0.102	0.247	0.145
DX	0.997	1.118	0.120	ESP	0.101	0.228	0.127
BRA	0.947	2.848	1.901	DX	0.100	0.109	0.009
AUS	0.732	1.658	0.926	AUS	0.053	0.144	0.091
KOR	0.298	1.557	1.259	GOL	0.012	0.033	0.022
JPN	−0.008	1.517	1.525	KOR	−0.017	0.118	0.135
GOL	−0.052	0.329	0.381	JPN	−0.029	0.137	0.166
IND	−0.083	1.397	1.480	IND	−0.054	0.126	0.180
CHN	−1.704	0.312	2.016	WTI	−0.114	0.066	0.181
WTI	−1.974	0.812	2.786	RUS	−0.214	0.156	0.370
RUS	−3.088	1.882	4.970	CHN	−0.293	0.027	0.320
VIX	−11.666	1.323	12.989	VIX	−0.975	0.132	1.106

Note: This table summarizes the average time-series market-wise frequency spillover indices on the bands corresponding to high-frequency (1–22 days) and low-frequency (above 22 days), which are derived from the spectral representation of volatility spillover network estimated by Eq. (1). "TS_{in}" and "TS_{out}" are market-wise in-strength and out-strength spillover sequences calculated by using the frequency spillover networks with the method as specified in Eq. (4). "NTS" is the frequency net total spillover calculated by using the frequency spillover networks with the method as specified in Eq. (5).

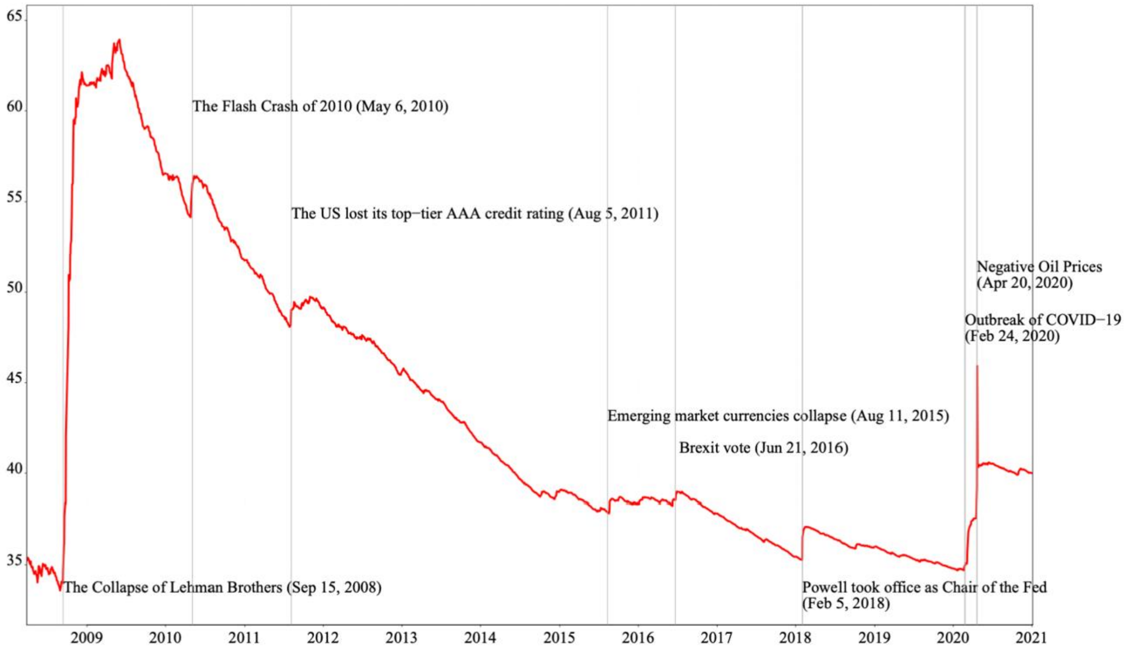


Fig. 1. Time plot of system-wise total spillovers. Note: this figure presents the time-series plot of system-wise total spillovers (STS), as estimated by Eq. (7). Key historical events are highlighted using grey vertical dashed lines.

4.3. Dynamics of the marginal spillover networks

So far, we have explored the patterns of pairwise and market-wise spillovers. Building on this foundation, we now extend our analysis to include system-wide spillover indices.

Fig. 1 presents the time-series plot of system-wise total spillovers (STS), as calculated by Eq. (7). Key historical events are highlighted using grey vertical dashed lines. Initially, we observe a sharp increase in spillover intensity during the 2008 global financial crisis, particularly following the collapse of Lehman Brothers on September 15, 2008. The spillover intensity surged from 35 basis points to a peak of approximately 65 basis points. Subsequently, the intensity of system-wise spillovers tended to revert to pre-crisis levels. However, several critical macroeconomic events are highlighted, including the Flash Crash of 2010, the downgrade of the US AAA credit rating in 2011, the collapse of emerging market currencies in 2015, the Brexit vote in 2016, the turnover of the Federal Reserve Board in 2018, and the COVID-19 outbreak in 2020. Each event correlates with noticeable increases and jumps in the spillover intensity, suggesting heightened transmission of financial shocks and structural changes in the spillover networks during these periods. Our findings are consistent with the evidence provided by Ait-Sahalia and Xiu (2016), who observed that jumps and co-jumps among financial markets can be driven by unexpected macroeconomic news.

Given the observed significant jumps in system-wide spillover intensity during several events, we are interested in the details of structural transformations within the spillover networks. Key questions include: How do network structures adapt during these episodes? Is there one particular dominant market that disproportionately drives these changes, or do most markets experience increased interconnectivity simultaneously?

To do this, we select an unprecedented event of WTI crude oil futures prices falling below zero on April 20, 2020, as a focal case study. This event, which was conducive to closing pressure and price manipulation in the crude oil market (Ge et al., 2022), offers a rare insight into the impact of an extraordinary and sudden distortion of one specific market on the dynamics and interconnections of other financial markets. Specifically, with the marginal global spillover networks, as shown in Eq. (8), we estimate the marginal changes in the spillover networks on the three adjacent trading days during the event: April 20, April 21, and April 22. Based on this representative case, we highlight the dynamic evolutionary features of systemic financial risk.

Fig. 2 depicts the marginal spillover networks on the three consecutive trading days: April 20, April 21, and April 22. Each node in the network represents a specific market, with the node size determined by the magnitude of the marginal net total spillovers ($MNTS$), as defined in Eq. 10). Larger node sizes indicate a greater increase in market net spillover. The arrow "$i \leftarrow j$" denotes marginal spillover from market j to i, with thicker arrows representing the greater increase in spillovers from market j to i. As shown in Fig. 2, we observe significant changes in the volatility spillover networks after the event.

First, after crude oil prices dropped below $0 on April 20, 2020, the spillover network became more intense and integrated, as evidenced by the thicker arrows and more linkages within the marginal spillover network on April 21. However, compared to the node sizes on April 20 in Panel A, Panel B shows a significant increase in the node size of the crude oil market, while the node sizes of other markets show a noticeable shrinkage. The evidence shows that, after the negative oil prices event, the crude oil market moved to the center stage of spillover networks. The increased spillovers out of the crude oil market were substantial and universal, resulting

in most other markets becoming receivers of volatility. Specifically, the VIX market acted as the leading volatility receiver after the event, as indicated by the thickest links in the network.

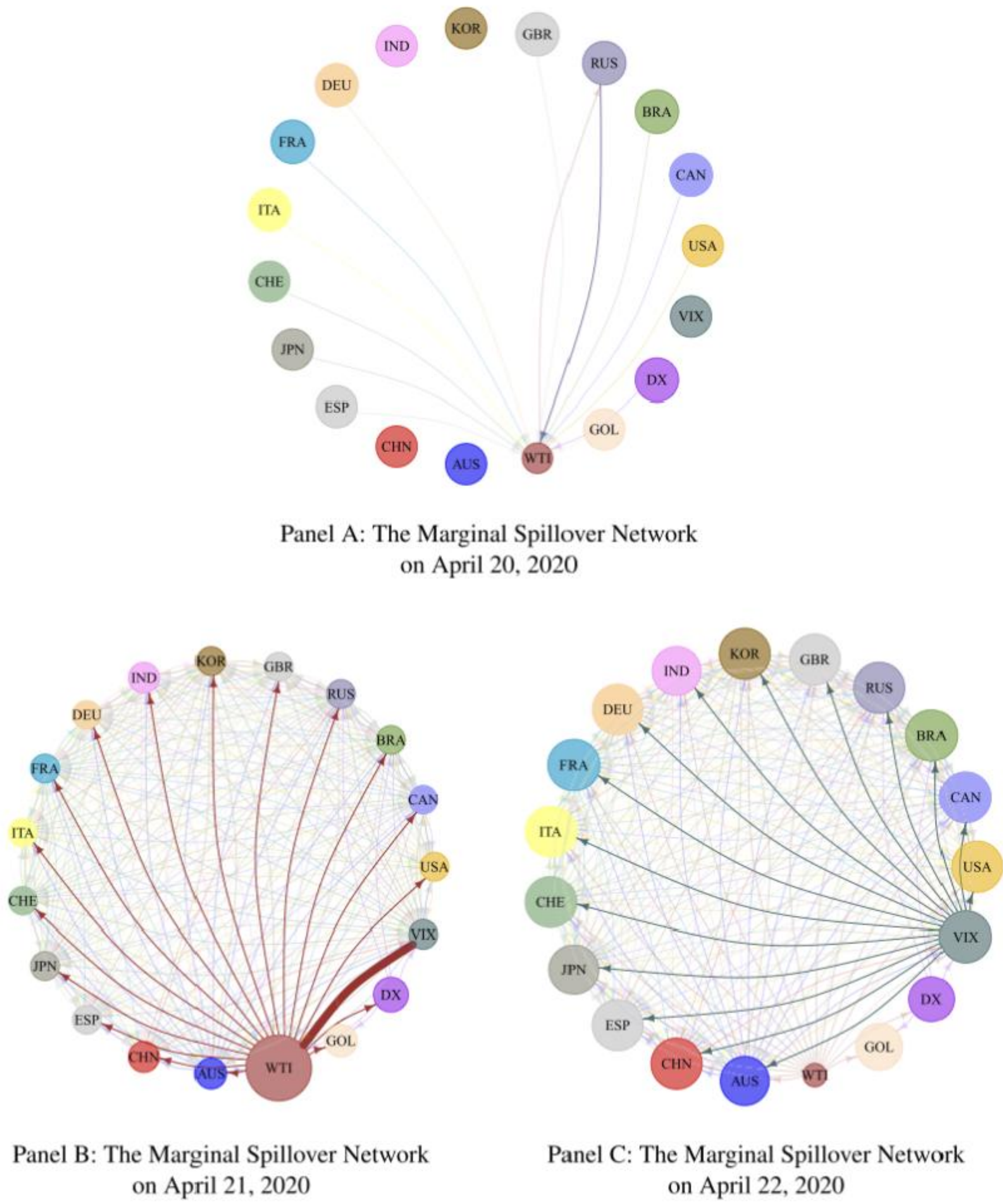
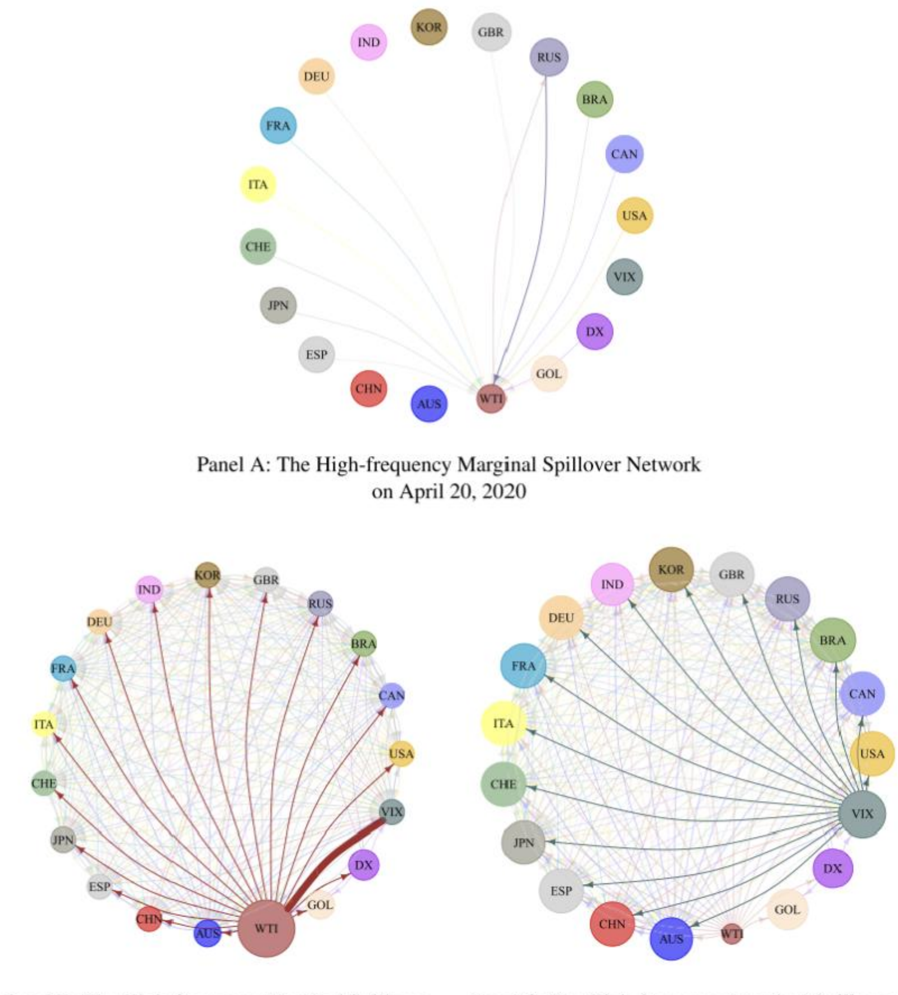


Fig. 2. The marginal spillover networks during the negative oil price event. Note: Panels A, B, and C of this figure depict the marginal spillover networks for the three consecutive trading days during the negative oil price event: April 20, 2020, April 21, 2020, and April 22, 2020, respectively. Each node in the network represents a distinct market, with the node size determined by the magnitude of the marginal net total spillovers (MNTS, as defined in Eq. 10). Larger node sizes indicate a greater increase in market net spillover. The arrow "$i \leftarrow j$" denotes marginal spillover from market j to i, with thicker arrows representing the greater increase in spillovers from market j to i.

Second, the post-event period on April 22, depicted in Panel C, shows a marked reduction in the node size of the crude oil market, indicating a significant decline in spillover effects from the crude oil market. However, the node sizes of other markets increased substantially, retaining their dense interconnectivity.

This suggests that the volatility, initially propagated by the crude oil market, continues to spill over to other markets significantly.

Next, we also compare the structural changes in spillover networks between short- and long-term frequencies, which are shown in Figs. 3 and 4, respectively. The spillover networks at high and low frequencies exhibit significant differences. Specifically, the patterns observed in high-frequency spillover networks align closely with those in overall spillover networks, characterized by similar complexity and integration in network structures. As shown in Fig. 3, the spillovers from the crude oil market mainly concentrate in the high-frequency range, positioning the crude oil market as the primary sender of high-frequency volatility spillovers after the event. Conversely, comparing Panels A and B in Fig. 4, we do not observe the pattern of one specific market dominating outward spillovers, as similarly noted in the overall and high-frequency spillovers. Instead, we find simultaneously intensified interconnections among several markets during the event, as evident by the dense edges and increased node sizes across several markets rather than just one.

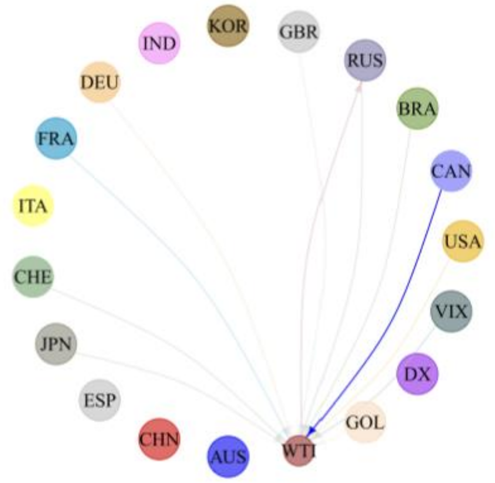


Panel A: The High-frequency Marginal Spillover Network on April 20, 2020

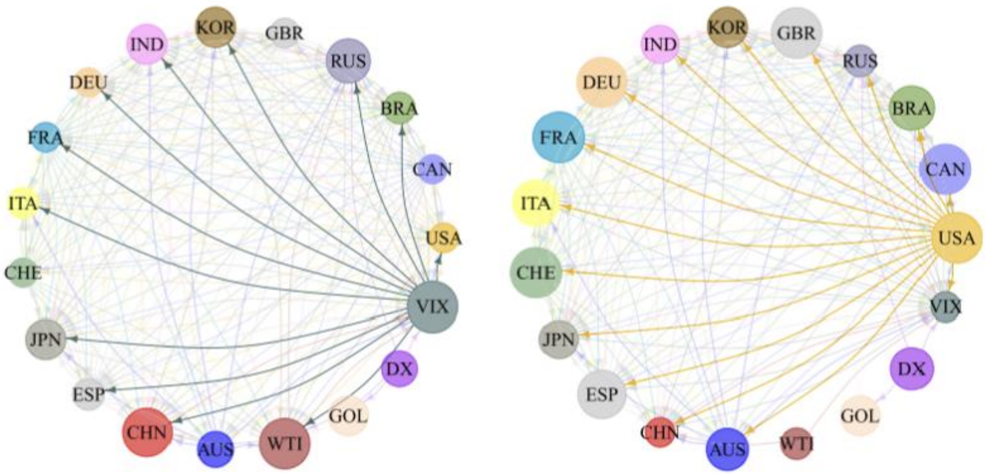
Panel B: The High-frequency Marginal Spillover Network on April 21, 2020

Panel C: The High-frequency Marginal Spillover Network on April 22, 2020

Fig. 3. The high-frequency marginal spillover networks during the negative oil price event. Note: Panels A, B, and C of this figure depict the high-frequency marginal spillover networks for the three consecutive trading days during the negative oil price event: April 20, 2020, April 21, 2020, and April 22, 2020, respectively. Each node in the network represents a distinct market, with the node size determined by the magnitude of the high-frequency marginal net total spillovers. Larger node sizes indicate a greater increase in market net spillover. The arrow "$i \leftarrow j$" denotes marginal spillover from market j to i, with thicker arrows representing the greater increase in spillovers from market j to i.



Panel A: The Low-frequency Marginal Spillover Network
on April 20, 2020



Panel B: The Low-frequency Marginal Spillover Network
on April 21, 2020

Panel C: The Low-frequency Marginal Spillover Network
on April 22, 2020

Fig. 4. The low-frequency marginal spillover networks during the negative oil price event. Note: Panels A, B, and C of this figure depict the low-frequency marginal spillover networks for the three consecutive trading days during the negative oil price event: April 20, 2020, April 21, 2020, and April 22, 2020, respectively. Each node in the network represents a distinct market, with the node size determined by the magnitude of the low-frequency marginal net total spillovers. Larger node sizes indicate a greater increase in market net spillover. The arrow "$i \leftarrow j$" denotes marginal spillover from market j to i, with thicker arrows representing the greater increase in spillovers from market j to i.

Lastly, we summarize the market-wise marginal net total spillovers and their high- and low-frequency components during the negative oil price event in order to clearly quantify the significant differences between heterogeneous frequency domains. Table 6 displays the results, with Panels A, B, and C detailing the situations on April 20, 21, and 22, respectively. We rank the markets according to their marginal net total spillovers, defined by Eq. (10).

The absolute magnitudes of marginal spillovers in Panel A are systematically lower than those in Panels B and C, indicating intensified outward and inward spillovers across markets after the shock. Comparing the structural changes in different frequencies after the event, as shown in columns (6) to (8), the marginal volatility spillovers in the high frequency (ranging from 47.605 to−11.486) occupy most of the overall marginal volatility spillovers (ranging from 49.195 to −6.612). In contrast, the marginal spillovers in the low frequency, ranging from −0.054 to 0.241, are significantly lower than those at high frequency. These findings suggest that the observed upward jump in connectedness among financial markets can be interpreted as a reflection of short-term informational dynamics.

Table 6
Marginal changes in spillovers at different frequencies during the negative oil price event.

Panel A: April 20, 2020				Panel B: April 21, 2020				Panel C: April 22, 2020			
Market (1)	Overall (2)	High (3)	Low (4)	Market (5)	Overall (6)	High (7)	Low (8)	Market (9)	Overall (10)	High (11)	Low (12)
RUS	0.276	0.214	0.002	WTI	49.195	47.605	0.070	VIX	6.477	11.380	−0.241
CAN	0.179	0.116	0.003	DX	−0.852	−0.635	−0.009	USA	4.143	3.060	0.052
GBR	0.159	0.118	0.003	GOL	−0.989	−0.937	−0.002	FRA	3.408	2.600	0.040
BRA	0.120	0.080	0.002	IND	−1.359	−1.403	0.003	DEU	3.277	2.503	0.037
FRA	0.119	0.079	0.002	CHN	−1.456	−2.040	0.030	GBR	3.228	2.363	0.042
ITA	0.116	0.096	0.001	AUS	−1.474	−1.311	−0.009	ITA	3.016	2.538	0.023
DEU	0.113	0.075	0.002	JPN	−1.530	−1.596	0.003	CAN	2.932	2.108	0.042
DX	0.110	0.090	0.001	KOR	−1.571	−1.525	0.000	ESP	2.889	2.378	0.025
ESP	0.096	0.081	0.001	CHE	−2.668	−1.982	−0.034	BRA	2.625	2.277	0.017
GOL	0.087	0.067	0.001	BRA	−2.953	−2.500	−0.022	CHE	2.517	1.880	0.032
USA	0.063	0.036	0.003	RUS	−3.002	−3.378	0.017	RUS	2.449	2.956	−0.023
JPN	0.059	0.035	0.001	ESP	−3.131	−2.546	−0.028	KOR	1.480	1.455	0.000
CHE	0.053	0.029	0.002	ITA	−3.274	−2.710	−0.027	CHN	1.439	2.028	−0.032
AUS	0.023	0.015	0.001	CAN	−3.298	−2.362	−0.047	JPN	1.422	1.521	−0.004
KOR	0.018	0.003	0.001	DEU	−3.490	−2.648	−0.040	IND	1.358	1.419	−0.004
IND	0.015	0.008	0.001	GBR	−3.490	−2.536	−0.046	AUS	1.344	1.211	0.008
CHN	0.012	0.004	0.001	FRA	−3.655	−2.761	−0.044	GOL	0.803	0.797	0.000
VIX	0.002	−0.016	0.001	USA	−4.392	−3.249	−0.054	DX	0.634	0.477	0.006
WTI	−1.621	−1.130	−0.030	VIX	−6.612	−11.486	0.241	WTI	−45.439	−44.950	−0.019

Note: This table summarizes the overall marginal net total spillovers and their high- and low-frequency domains during the negative oil price event on April 20, 2020, with Panels A, B, and C detailing the situations on April 20, 21, and 22, respectively. We rank the markets according to their marginal net total spillovers, defined by Eq. (10).

4.4. Economic explanations

This section delves deeper into the underlying forces driving global spillovers. Furthermore, we meticulously investigate the interplay between sentiment and liquidity factors, elucidating the complex mechanisms that govern these spillovers.

4.4.1. Results for determinants of dynamic changes in global spillovers

First, we estimate the regression (14) with the dependent variables of overall, high-, and low-frequency marginal spillover indices. We focus on the relative importance of sentiment, liquidity, and other fundamental factors in driving global financial spillovers across different frequency domains.

Given that dynamic changes in volatility spillovers are primarily short-term, the regression is estimated at a daily frequency. Notably, fundamental indicators are at a relatively low frequency. Specifically, the IMF provides monthly bilateral trade and semi-annual portfolio investment flow data. Following the experience of dealing with mixed-frequency data in asset pricing and corporate finance research (e.g., Fama and French, 1992, 1993, 2015), we transfer the monthly and semi-annual data to the daily data by assigning the monthly or semi-annual value to every trading day in the specific month or half year.

Table 7 presents the analysis results. Initially, columns (1) to (3) demonstrate that the degree of relative optimism significantly influences the variation in overall spillovers. Specifically, the coefficients of on the overall spillover measure range from 0.176 to 0.188, which are statistically significant at the 1 % level. The positive coefficients suggest that an increase in relative optimism escalates the outward volatility spillover. A high degree of relative optimism seems to encourage investors to engage in a “race to optimism” strategy by reallocating the assets toward markets perceived as more optimistic, thus enhancing the systematic importance of these markets.

Table 7
Determinants of dynamic changes in spillovers networks.

	Overall			High-frequency			Low-frequency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$SENT$	0.188***		0.176***	0.197***		0.185***	0.060		0.054
	(0.057)		(0.058)	(0.059)		(0.059)	(0.037)		(0.037)
PI		0.736**	0.782**		0.715**	0.759**		0.584**	0.618***
		(0.323)	(0.327)		(0.330)	(0.335)		(0.236)	(0.232)
LIQ		0.279***	0.263***		0.283***	0.268***		0.146***	0.134***
		(0.068)	(0.067)		(0.069)	(0.069)		(0.039)	(0.038)
UMP		0.085	0.073		0.066	0.054		0.170**	0.159**
		(0.076)	(0.074)		(0.075)	(0.073)		(0.070)	(0.068)
TRA		0.142	0.187		0.098	0.147		0.354	0.356
		(0.323)	(0.335)		(0.329)	(0.340)		(0.244)	(0.255)
INT			0.019**			0.019*			0.012***
			(0.010)			(0.010)			(0.004)
GDP			0.067			0.055			0.110*
			(0.059)			(0.061)			(0.060)
$Inflation$			0.001			0.001			−0.001
			(0.003)			(0.003)			(0.002)
$SKEW$			0.012***			0.010***			0.018***
			(0.003)			(0.003)			(0.003)
RET			0.940			1.125			−0.547
			(0.955)			(0.993)			(0.706)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040
Adjusted R^2	0.091	0.091	0.091	0.095	0.095	0.096	0.187	0.187	0.187

Note: This table summarizes the results of the regression (14) with the dependent variables of overall, high-, and low-frequency marginal spillover indices. $SENT_{i\leftarrow j,t}$ is the difference in investor sentiment between market j and i, suggesting the relative optimism of market j against market i. $LIQ_{i\leftarrow j}$ is the difference in market liquidity between markets j and i. $UMP_{i\leftarrow j}$ assesses the disparity in unconventional monetary policies between markets j and i, while $TRA_{i\leftarrow j}$ and $PI_{i\leftarrow j}$ measure the bilateral trade and portfolio investment from market j to market i, respectively, normalized by the total trade and portfolio inflows of market i. Control variables account for differences in GDP, short-term interest rates (denoted as INT), inflation, skewness (denoted as $SKEW$), and returns (denoted as RET) between the markets. The model also includes market-by-market (μ_{ij}) and time-specific (γ_t) fixed effects. We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Standard errors are reported in parentheses below. *,** and *** denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels.

Moreover, our analysis reveals that investor sentiment predominantly contributes to high-frequency spillovers rather than low-frequency ones. The coefficients of relative optimism on the high-frequency spillover index range from 0.185 to 0.197 and are statistically significant at the 1% level. In contrast, those on the low-frequency spillover indices are not significant, with values ranging from 0.054 to 0.060. Our findings might relate to the sentiment-induced temporary mispricing. Previous empirical studies have demonstrated a notable short-term influence of investor sentiment on stock returns and volatility (Da et al., 2015, 2021). Investor sentiment contributes to a temporary price deviation that is likely to be corrected rapidly after the disclosure of fundamental values, leading to contemporaneous sentiment-induced volatility (Da et al., 2015). Our results are consistent with Hypothesis 1 and contribute to the existing literature by demonstrating that sentiment-induced spillovers are also transient.

Second, the evidence indicates that long-term spillovers are primarily driven by liquidity factors. Specifically, portfolio investment flows have a persistent and all-around impact on volatility transmissions. The coefficients of PI, ranging from 0.618 to 0.782, are statistically significant at the minimum of the 5% level across various frequency domains. One plausible mechanism, as identified by Bartram et al. (2015), is the foreign ownership channel: stocks with high levels of foreign ownership are more susceptible to variations in foreign stock returns, thereby inducing correlations among international financial markets. Additionally, Karolyi et al. (2012) propose another mechanism, illustrating that capital flows, predominantly driven by institutional investors, contribute to greater contagion due to their related trading activities.

Our analysis also reveals that variations in market liquidity between markets significantly and positively affect both high- and low-frequency spillovers, suggesting that markets with higher liquidity levels exert a more substantial influence on less liquid markets. These findings align with Guidolin et al. (2019), who propose a flight-to-liquidity channel to explain contagion spillovers, positing that shocks tend to prompt the demand and attraction for highly liquid markets.

Furthermore, variations in unconventional monetary policy predominantly trigger long-term volatility spillovers. The coefficients of UMP on the low-frequency spillover components, ranging from 0.159 to 0.170, are significant at the 5% level. However, there is no significant evidence that unconventional monetary policy impacts short-term volatility spillovers. Furthermore, gaps in interest rate policy also significantly affect both short- and long-term volatility spillovers, with more statistical significance on long-term spillovers. Our findings align with those of Yang and Zhou (2017), indicating that unconventional monetary and interest rate policies trigger volatility spillovers to other countries.

Turning to other economic linkages, while our analysis does not reveal a significant impact of trade linkages on spillovers, we still observe a larger effect of trade linkages on low-frequency spillovers (with coefficients ranging between 0.354 and 0.356) compared to high-frequency ones (ranging between 0.098 and 0.147). Among other economic similarities, differences in GDP demonstrate a significantly positive impact on long-term spillovers, with coefficients significant at the 10% level.

Given that sentiment factors primarily contribute to high-frequency spillovers rather than low-frequency components, our results verify Hypothesis 2, underscoring that long-term spillovers are mainly driven by liquidity and other fundamental linkages. This observation aligns with Bekaert et al. (2009), who suggests that economic and financial market integration primarily induces long-term movements in international financial markets. We particularly emphasize that liquidity-related factors—including capital flow, market liquidity, and monetary policies—serve as more significant and comprehensive drivers of spillovers across financial markets compared to other economic linkages and similarities.

Next, as most existing studies on sentiment focus on one source of information at a time, we are interested in whether global financial spillovers react to social media and news media in a systematically different way. To do this, we directly compare sentiment from news and social media sources and thus provide new empirical facts on their relationship with global financial spillovers. Specifically, we revisit the regression (14), regressing bilateral marginal spillovers on the relative optimism measures derived from the news (denoted as $SENT_{new}$) or social media ($SENT_{social}$) sources. Table 8 shows the results.

Table 8
Heterogeneity results for sentiment sources.

	Overall			High-frequency			Low-frequency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$SENT_{news}$	0.153***		0.135**	0.161***		0.142**	0.047		0.043
	(0.052)		(0.054)	(0.053)		(0.056)	(0.033)		(0.037)
$SENT_{social}$		0.109***	0.040		0.115***	0.043		0.030	0.008
		(0.041)	(0.039)		(0.042)	(0.040)		(0.028)	(0.030)
PI	0.780**	0.788**	0.784**	0.757**	0.765**	0.761**	0.618***	0.620***	0.619***
	(0.328)	(0.326)	(0.328)	(0.336)	(0.334)	(0.336)	(0.233)	(0.232)	(0.233)
LIQ	0.262***	0.271***	0.263***	0.267***	0.276***	0.267***	0.134***	0.137***	0.134***
	(0.067)	(0.067)	(0.067)	(0.069)	(0.068)	(0.069)	(0.038)	(0.038)	(0.038)
UMP	0.071	0.077	0.072	0.052	0.059	0.053	0.159**	0.161**	0.159**
	(0.074)	(0.075)	(0.074)	(0.073)	(0.074)	(0.073)	(0.068)	(0.068)	(0.068)
TRA	0.189	0.166	0.187	0.150	0.126	0.148	0.357	0.350	0.357
	(0.335)	(0.336)	(0.335)	(0.339)	(0.340)	(0.339)	(0.255)	(0.253)	(0.255)
INT	0.019**	0.019**	0.019**	0.019*	0.019*	0.019*	0.012***	0.012***	0.012***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)	(0.004)
GDP	0.066	0.067	0.066	0.055	0.055	0.055	0.110*	0.110*	0.110*
	(0.059)	(0.059)	(0.059)	(0.061)	(0.061)	(0.061)	(0.060)	(0.060)	(0.060)
$Inflation$	0.001	0.001	0.001	0.001	0.001	0.001	−0.001	−0.001	−0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
$SKEW$	0.012***	0.012***	0.012***	0.010***	0.010***	0.010***	0.018***	0.018***	0.018***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
RET	0.941	0.937	0.940	1.126	1.122	1.125	−0.547	−0.548	−0.547
	(0.955)	(0.957)	(0.955)	(0.994)	(0.995)	(0.993)	(0.706)	(0.705)	(0.706)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040
Adjusted R^2	0.091	0.091	0.091	0.095	0.095	0.095	0.187	0.187	0.187

Note: This table summarizes the results of the regression (14) with the dependent variables of overall, high-, and low-frequency marginal spillover indices. $SENT_{news}$ ($SENT_{social}$) is the difference in investor sentiment between markets sourced from news (social media). $LIQ_{i\leftarrow j}$ is the difference in market liquidity between markets j and i. $UMP_{i\leftarrow j}$ assesses the disparity in unconventional monetary policies between markets j and i, while $TRA_{i\leftarrow j}$ and $PI_{i\leftarrow j}$ measure the bilateral trade and portfolio investment from market j to market i, respectively, normalized by the total trade and portfolio inflows of market i. Control variables account for differences in GDP, short-term interest rates (denoted as INT), inflation, skewness (denoted as $SKEW$), and returns (denoted as RET) between the markets. The model also includes market-by-market (μ_{ij}) and time-specific (γ_t) fixed effects. We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Standard errors are reported in parentheses below. *,** and *** denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels.

Columns (1) through (6) of Table 8 show that news sentiment exerts a more substantial influence on financial spillovers, particularly on high-frequency spillovers, compared to social media sentiment. This is evidenced by the larger magnitude of coefficients for $SENT_{new}$, which range from 0.135 to 0.153, as opposed to those for $SENT_{social}$, ranging from 0.040 to 0.109. Moreover, when both sources of sentiment are included in the regression analysis simultaneously, news sentiment continues to dominate in explanatory power for global financial spillovers. Specifically, as shown in columns (3) and (6), the coefficient for $SENT_{new}$ maintains its significance, while the coefficient for S_{social} becomes insignificant. In contrast, columns (7) through (9) indicate that although neither news nor social media sentiment significantly influences low-frequency spillovers, the coefficients for news sentiment (ranging from 0.043 to 0.047) are still larger than those for social media sentiment (ranging from 0.008 to 0.030).

The results that news sentiment dominates social media sentiment in predicting financial spillovers can be explained by the findings of Jiao et al. (2020), who note that social media repeats existing news media signals, and stock market returns are found to respond less to stale information (Tetlock, 2011). Additionally, these findings can be supported by the theoretical predictions of Goldstein et al. (2024), who suggest that social media information may worsen the trading of investors who are already well-informed by the qualified news, subsequently reducing the market liquidity and efficiency. Our results confirm the important role of news media in driving financial spillovers between markets.

4.4.2. Interaction effect between market liquidity and capital flows

So far, we have observed the heterogeneous roles of sentiment and liquidity factors in driving global financial spillovers. We now delve deeper into the complex interplay between liquidity factors and investor sentiment. Initially, we conduct an empirical test to assess the interactions between market liquidity and funding liquidity and their effects on volatility spillovers across financial markets. This test aims to validate the theoretical prediction proposed by Brunnermeier and Pedersen (2009), who argues that market liquidity and funding liquidity are mutually reinforcing and lead to increased volatility co-movements across securities.

To do this, we construct two indicator variables. The first indicator, $1\{LIQ \geq q_{0.75}\}$, is assigned a value of one if the difference in market liquidity between markets j and i, $LIQ_{i \leftarrow j}$, exceeds its 75% sample quantile, and zero otherwise. The second indicator, $1\{PI \geq q_{0.75}\}$, equals one if the portfolio investment flow from country j to i, $PI_{i \leftarrow j}$, surpasses its 75% sample quantile, and zero otherwise. In the first test, we employ the interaction term $LIQ \times 1\{PI \geq q_{0.75}\}$ into the regression (14). This interaction term examines the increase in the impact of market liquidity on financial spillovers under conditions of high portfolio investment flows compared to the influence under the conditions of normal capital flows, which is characterized by the magnitude of LIQ alone. In the second test, we incorporate the interaction term $PI \times 1\{LIQ \geq q_{0.75}\}$ into the regression (14). This interaction term examines the increasing influence of capital flows on financial spillovers during periods characterized by a large disparity in market liquidity compared to the influence under the normal conditions of market liquidity, which is characterized by the magnitude of PI alone. The results for

these tests are displayed in Table 9, with Panels A and B detailing the outcomes of the first and second tests, respectively.

Table 9
The interaction effect of market liquidity and portfolio investment flows.

	Overall		High-frequency		Low-frequency	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: results of the interaction effect of portfolio investment flows on market liquidity						
$LIQ \times 1\{PI \geq q_{0.75}\}$	0.189***	0.183**	0.200***	0.194***	0.050	0.048
	(0.073)	(0.073)	(0.072)	(0.072)	(0.069)	(0.069)
LIQ	0.239***	0.227***	0.241***	0.229***	0.131***	0.126***
	(0.043)	(0.043)	(0.043)	(0.043)	(0.041)	(0.041)
Adjusted R^2	0.091	0.091	0.095	0.096	0.187	0.187
Panel B: results of the interaction effect of market liquidity on portfolio investment flows						
$PI \times 1\{LIQ \geq q_{0.75}\}$	−0.042	−0.051	−0.036	−0.044	−0.063	−0.078
	(0.087)	(0.087)	(0.087)	(0.087)	(0.082)	(0.083)
PI	0.824***	0.862***	0.797***	0.836***	0.671***	0.687***
	(0.256)	(0.258)	(0.256)	(0.257)	(0.242)	(0.244)
Adjusted R^2	0.091	0.091	0.095	0.095	0.187	0.187
Control	No	Yes	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040

Note: Panel A summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of the difference in market liquidity (LIQ) with an indicator $1\{PI \geq q_{0.75}\}$ that equals one if the portfolio investment flow between markets surpasses its 75 % sample quantile and zero otherwise. Panel B summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{LIQ \geq q_{0.75}\}$ that equals one if the difference in market liquidity between markets exceeds its 75 % sample quantile and zero otherwise. Other control variables are the same as regression (14). We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Reported are the regression slopes, standard errors in the parentheses, and R^2s. *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels, respectively.

We observe an asymmetric effect in the interaction between market liquidity and capital flows on driving global spillovers. Specifically, as presented in Panel A of Table 9, the coefficients of the interaction terms $LIQ \times 1\{PI \geq q_{0.75}\}$ on overall spillovers and their high-frequency components are significantly positive, with magnitudes ranging from 0.183 to 0.200. The coefficients of LIQ range from 0.227 to 0.241. The ratio of these two sets of coefficients, approximately 83%, suggests that the impact of market liquidity on overall and short-term spillovers increases by approximately 83% when accompanied by elevated levels of bilateral capital flows, compared to the benchmark situation. Turning to the impact on long-run spillovers, although the coefficients of the interaction terms on low-frequency spillovers are statistically insignificant, their magnitudes, ranging from 0.048 to 0.050, constitute approximately 38% of the magnitudes of coefficients for LIQ on low-frequency spillovers, which range from 0.126 to 0.131. This proportion underscores that capital flows enhance the impact of market liquidity on long-run spillover components with considerable economic significance. Capital flow thus provides an important channel for spillovers through market liquidity.

In contrast, results for the second test, detailed in Panel B of Table 9, reveal that the coefficients of the interaction terms $PI \times 1\{LIQ \geq q_{0.75}\}$ are insignificant. This suggests that the impact of the capital flows on global spillovers remains similar between conditions of high and normal market liquidity gaps.

Our empirical findings partially corroborate the theoretical prediction by Brunnermeier and Pedersen (2009) that bilateral funding flows intensify the volatility spillovers from more liquid markets to less liquid markets. Capital flows emerge as a critical channel in adjusting market liquidity and triggering global spillovers. As documented by Karolyi et al. (2012), the funding inflows tend to release the market liquidity in less liquid markets, and the related trading behavior of institutional traders further enhances the interconnectivity between markets.

4.4.3. Interaction effect between investor sentiment and capital flows

Motivated by literature underscoring the interrelation among investor sentiment, capital flows, and portfolio choices (e.g., Dumas et al., 2009; Galaritis et al., 2018; Benhima and Cordonier, 2022), our study seeks to delve deeper into how the interplay between sentiment and capital flows affects global financial spillovers.

Similarly, we define another indicator variable, $1\{SENT \geq q_{0.75}\}$, which is assigned a value of one if the relative optimism of market j against market i, denoted by $SENT_{i\leftarrow j}$, surpasses the 75% quantile of its sample distribution, and zero otherwise. For the first analysis, we integrate the interaction term $SENT \times 1\{PI \geq q_{0.75}\}$ into the regression (14). This interaction term assesses the increase in the influence of sentiment on financial spillovers in scenarios of elevated portfolio investment flows compared to the influence under the scenarios of normal portfolio investment flows, quantified by the magnitude of $SENT$ alone. In the second analysis, we incorporate the interaction term $PI \times 1\{SENT \geq q_{0.75}\}$ into the regression. This interaction term investigates the incremental effects of capital flows on financial spillovers during periods marked by significant disparities in investor sentiment compared to the effects under normal conditions, which are quantified by the magnitude of PI alone. The findings from these analyses are presented in Table 10, with Panel A detailing the results of the first analysis and Panel B those of the second.

Table 10
The interaction effect of sentiment and portfolio investment flows.

	Overall		High-frequency		Low-frequency	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: results of the interaction effect of portfolio investment flows on sentiment						
$SENT \times 1\{PI \geq q_{0.75}\}$	0.027	0.025	0.035	0.033	−0.029	−0.031
	(0.082)	(0.082)	(0.082)	(0.082)	(0.078)	(0.078)
$SENT$	0.181***	0.169***	0.188***	0.176***	0.067	0.062
	(0.044)	(0.044)	(0.044)	(0.044)	(0.042)	(0.042)
Adjusted R^2	0.091	0.091	0.095	0.095	0.187	0.187
Panel B: results of the interaction effect of sentiment on portfolio investment flows						
$PI \times 1\{SENT \geq q_{0.75}\}$	0.217***	0.195**	0.234***	0.211***	0.034	0.021
	(0.077)	(0.077)	(0.077)	(0.077)	(0.073)	(0.073)
PI	0.764***	0.736***	0.737***	0.710***	0.637***	0.615**
	(0.252)	(0.254)	(0.251)	(0.253)	(0.238)	(0.240)
Adjusted R^2	0.091	0.091	0.095	0.095	0.187	0.187
Control	No	Yes	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040

Note: Panel A summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of relative optimism ($SENT$) with an indicator $1\{PI \geq q_{0.75}\}$ that equals one if the portfolio investment flow between markets surpasses its 75 % sample quantile and zero otherwise. Panel B summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{SENT \geq q_{0.75}\}$ that equals one if the relative optimism between markets exceeds its 75 % sample quantile and zero otherwise. Other control variables are the same as regression (14). We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Reported are the regression slopes, standard errors in the parentheses, and R^2s. *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels, respectively.

An asymmetric effect is evident in how portfolio investment and investor sentiment interact to influence global spillovers. Specifically, as shown in Panel A of Table 10, the coefficients of the interaction term $SENT \times 1\{PI \geq q_{0.75}\}$, on overall spillovers and their frequency-domain components, are insignificant, indicating that high capital flows do not significantly amplify the influence of relative optimism on spillovers. Conversely, the findings in Panel B of Table 10 demonstrate that the coefficients of the interaction term $PI \times 1\{SENT \geq q_{0.75}\}$ on overall spillovers and the high-frequency components are significant at the 1% level, exhibiting values ranging from 0.195 to 0.234. The coefficients for PI alone range from 0.710 to 0.764. The ratio of these two sets of coefficients, approximately 30%, illustrates that the effects of capital flows on overall and short-term volatility spillovers are enhanced by approximately 30% when coinciding with high levels of relative optimism, in comparison to the baseline situation in sentiment.

Our results are supported by the findings of Benhima and Cordonier (2022), who suggest that sentiment shocks can generate procyclical capital flows due to foreigners' limited information about domestic fundamentals. However, there is no significant evidence that investor sentiment directly augments the impact of capital flows on the long-term components of spillovers.

In short, our analysis illustrates the comprehensive impact of capital flows on global financial spillovers across various frequency domains. Investor sentiment appears to amplify the effects of capital flows in driving these spillovers, particularly within the high-frequency domains. However, the factors contributing to the impact of capital flows on long-term spillovers remain an unresolved issue. Besides investor sentiment, a possible mechanism might be linked to the interplay between monetary policy and capital flows. Specifically, variations in unconventional monetary policies are documented to cause capital flows from countries implementing such policies to those without or with less extensive unconventional monetary policies (e.g., Kiendrebeogo, 2016; Anaya et al., 2017). As shown in our baseline regression, the variation in unconventional monetary policies significantly contributes to long-run spillovers. Based on this finding, we hypothesize that unconventional monetary policy might play a significant interactive role in driving global financial spillovers by influencing capital flows.

To explore this hypothesis, we construct an indicator variable, $1\{UMP \geq q_{0.75}\}$, which is assigned a value of one if the differences in unconventional monetary policies between countries j and i, denoted by $UMP_{i \leftarrow j}$, exceed the 75th percentile and zero otherwise. We incorporate the interaction term $PI \times 1\{UMP \geq q_{0.75}\}$ into the regression (14). This interaction term assesses the increased impact of capital flows on financial spillovers in scenarios characterized by high disparities in UMP between countries, compared to scenarios with normal UMP conditions, which is quantified by the magnitude of PI alone. The results of this analysis are presented in Panel A of Table 11.

Table 11
The interaction effect of sentiment, portfolio investment flows, and unconventional monetary policy.

	Overall		High-frequency		Low-frequency	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: results of the interaction effect of unconventional monetary policy on portfolio investment flows						
$PI \times 1\{UMP \geq q_{0.75}\}$	0.017	0.001	0.005	−0.012	0.083	0.081
	(0.066)	(0.066)	(0.065)	(0.066)	(0.062)	(0.062)
PI	0.800***	0.783***	0.780***	0.763***	0.616***	0.600**
	(0.252)	(0.254)	(0.251)	(0.253)	(0.238)	(0.240)
Adjusted R^2	0.090	0.091	0.095	0.095	0.187	0.187
Panel B: role of sentiment in the interaction effect of unconventional monetary policy on portfolio investment flows						
$PI \times 1\{UMP \geq q_{0.75}\} \times 1\{SENT \geq q_{0.75}\}$	0.513***	0.488***	0.510***	0.485***	0.331***	0.314***
	(0.123)	(0.123)	(0.123)	(0.123)	(0.117)	(0.117)
$PI \times 1\{UMP \geq q_{0.75}\}$	−0.110	−0.118	−0.121*	−0.130*	0.001	0.004
	(0.072)	(0.073)	(0.072)	(0.072)	(0.068)	(0.069)
PI	0.889***	0.860***	0.869***	0.840***	0.669***	0.649***
	(0.252)	(0.254)	(0.252)	(0.254)	(0.239)	(0.241)
Adjusted R^2	0.091	0.091	0.095	0.095	0.187	0.187
Control	No	Yes	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040

Note: Panel A summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{UMP \geq q_{0.75}\}$ that equals one if the gap in unconventional monetary policy between markets surpasses its 75 % sample quantile and zero otherwise. Panel B summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{SENT \geq q_{0.75}\} \times 1\{UMP \geq q_{0.75}\}$ that equals one if both the relative optimism and the gaps in unconventional monetary policy between markets exceed their 75 % sample quantile and zero otherwise. Other control variables are the same as regression (14). We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Reported are the regression slopes, standard errors in the parentheses, and R^2s. *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels, respectively.

As demonstrated in Panel A of Table 11, we do not find significant evidence supporting the hypothesis that high disparities in unconventional monetary policies amplify the impact of portfolio investment flows on financial spillovers; the coefficients of the interaction term $PI \times 1\{UMP \geq q_{0.75}\}$ on overall spillovers and their frequency components are positive but not statistically significant. We build on the findings of Dumas et al. (2009), who report that overly optimistic investors tend to overreact to public signals, thus magnifying the impact of public policies on asset prices. We test whether heightened investor optimism amplifies the market response to unconventional monetary policies, which are posited to potentially enhance capital flows and generate financial spillovers. This investigation involves incorporating another interaction term, $PI \times 1\{UMP \geq q_{0.75}\} \times 1\{SENT \geq q_{0.75}\}$, into our regression analysis. This interaction term captures the increased impact of capital flows on spillovers under conditions of both high disparities in unconventional monetary policies and high levels of relative optimism, compared to the benchmark situation, which is quantified solely by the magnitude of PI. Panel B of Table 11 shows the results.

As shown in Panel B of Table 11, the coefficients of interaction term $PI \times 1\{UMP \geq q_{0.75}\} \times 1\{SENT \geq q_{0.75}\}$, which range from 0.314 to 0.513, are significantly positive across overall spillovers and all frequency components. The coefficients for PI range from 0.649 to 0.899. The ratio of these two groups of coefficients, approximately 50%, illustrates that the effects of capital flows on volatility spillovers are enhanced by approximately 50% in scenarios characterized by high levels of both investor optimism and unconventional monetary policies, compared to the baseline condition. This evidence underscores the crucial role of investor sentiment in amplifying the interaction between unconventional monetary policies and capital flows in driving financial spillovers. Although we do not observe direct evidence that investor sentiment significantly triggers long-term spillovers, high relative optimism substantially amplifies the influence of unconventional monetary policies on capital flows, which in turn enhances long-term spillovers.

In sum, our findings support the mechanism proposed by Kiendrebeogo (2016); Anaya et al. (2017). They suggest that variations in unconventional monetary policies tend to drive capital flows between countries, thereby leading to financial spillovers. However, our analysis further specifies that this mechanism is significantly pronounced only during periods of high relative optimism. This aligns with the findings of Dumas et al. (2009) that overconfident investors are more prone to overreacting to policies, thereby exerting excessive influence on financial markets. These findings broaden our understanding of the critical intermediary role that market sentiment plays between macroeconomic policies and global financial stability; although sentiment's direct impact is transient, overoptimism can amplify policy responses, thereby exerting a prolonged spillover across financial markets.

5. Robustness check

In this section, we first present robust results using an orthogonalized measure of investor sentiment. We then extend our analytical framework to study currency risk spillovers, both to verify the robustness of our results in other markets and to aid global investors in more effectively managing their currency risks.

5.1. Using an orthogonalized measure of sentiment

Behavioral finance theory characterizes investor sentiment as primarily an irrational belief that exists in addition to rational fundamentals (Zhou, 2018). Therefore, investor sentiment and fundamental factors are expected to contain distinct sets of information. However, we acknowledge that our approach to constructing investor sentiment through news and social media content may inadvertently incorporate some fundamental information.

To address this issue and test the robustness of our results, we follow Baker and Wurgler (2006), who construct sentiment proxies orthogonal to macroeconomic conditions. Specifically, we orthogonalize our investor sentiment measure by regressing it on liquidity and other fundamentals—trade flows, interest rates, economic growth, and inflation—and use the residuals as the adjusted sentiment. The modified measure is represented by $SENT^{\perp}_{i\leftarrow j}$. This approach filters out information on the fundamentals, providing a cleaner measure of investor sentiment toward assets. Using the orthogonalized measure of sentiment, we re-estimate the baseline regression (14).

We first test the robustness of our baseline results, using the alternative sentiment measure, $SENT^{\perp}_{i\leftarrow j}$. As shown in Table A1, we confirm our main findings that investor sentiment primarily drives short-term spillovers. The coefficients on $SENT^{\perp}$ for short-run spillovers range from 0.185 to 0.218 and are statistically significant at the 1% level; by contrast, the corresponding coefficients for long-run spillovers are smaller ranging from 0.054 to 0.068 and are statistically insignificant. Then, we revisit the heterogeneous sources of sentiment using the alternative sentiment measure. Results in Table A2 indicate that news-based sentiment exerts a stronger impact on financial spillovers than social-media-based sentiment, consistent with the previous findings.

We further examine the robustness of the results for the interaction effects. Table A3 reports robustness results for the interaction between sentiment and capital flows in shaping global financial spillovers. Consistent with our primary findings, we still identify an asymmetric interaction: high capital flows do not significantly amplify the effect of relative optimism on spillovers, whereas high relative optimism significantly magnifies the impact of capital flows on overall and short-run volatility spillovers. Table A4 reports robustness results on the interaction between sentiment, unconventional monetary policy, and capital flows in driving global financial spillovers. We confirm the robust results that the coefficients of the interaction term $PI \times 1\{UMP \geq q_{0.75}\} \times 1\{SENT^{\perp} \geq q_{0.75}\}$, ranging from 0.336 to 0.588, are positively significant across overall spillovers and all frequency components. The results consistently demonstrate that heightened investor optimism intensifies the market response to unconventional monetary policies, which are believed to bolster capital flows and produce financial spillovers.

5.2. Additional analysis on currency spillovers

Our paper develops a comprehensive framework designed to enable global investors to analyze volatility and risk comovement across international financial markets. Given that currency risk significantly influences portfolio performance for global investors (Ang and Bekaert, 2002; Lioui and Poncet, 2003), we further extend our framework to examine currency risk spillovers. This extension serves dual purposes: verifying the robustness of our results within currency markets and assisting global investors in more effectively managing their currency risks.

To construct exchange rate spillover networks for currencies, we collect daily exchange rates of related currencies from Datastream, including the US Dollar Index (USA), onshore Chinese yuan (CHN), the Euro (EUR), the Pound Sterling (GBR), the Australian Dollar (AUS), the Canadian Dollar (CAN), the Japanese Yen (JPN), the Korean Won (KOR), the Brazilian Real (BRA), the Indian Rupee (IND), the Russian Ruble (RUS), and the Swiss Franc (CHE). Except for the US Dollar Index, all other exchange rates of the currencies are their prices in terms of the US Dollar.

We first estimate the average time-series currency-wise spillover indices. Table A5 reports the results. In the column labeled "NTS", the US Dollar emerges as the largest net sender of volatility, with a net spillover intensity of 26.494 basis points. This underscores the USD's central role in the international monetary system: it predominantly transmits volatility to others rather than being influenced by other currencies. Consistent with our baseline results in stock and commodity markets, the United States is the most influential economy in both financial and currency markets. Moreover, currency spillovers are substantially larger than spillovers among financial markets, indicating stronger contagion in currencies. Next, we further decompose the currency spillovers into the short- and long-term currency spillovers.

As shown in Table A6, high-frequency components dominate: their net total spillovers range from 24.951 to -16.935 across currencies and account for about 95% of the overall net total spillovers (26.494 to -17.841). Low-frequency components are smaller ranging from 1.310 to -0.997 and comprise the remaining 5%. These results in the currency market are consistent with our findings in financial markets.

Based on our framework, we examine the determinants of currency-risk spillovers. Table A7 reports the results. Consistent with our findings in financial markets, we find that investor sentiment primarily drives short-run spillovers. Specifically, the coefficients on $SENT^{\perp}$ for short-run spillovers range between 0.058 and 0.061, and they are statistically significant at the 5% level. In contrast, the coefficients for long-run spillovers are considerably smaller, approximately 0.030, and are not statistically significant. Long-run currency spillovers are predominantly influenced by trade flows.

In summary, our primary findings demonstrate considerable robustness within global currency markets. Global investors should recognize the significant influence of sentiment on asset comovement and its role in driving currency risk spillovers when making global asset allocation decisions.

6. Conclusions

This paper contributes to the ongoing debate about the determinants of market spillovers, highlighting the pivotal roles of investor sentiment, liquidity, and fundamental linkages. We extend the Diebold-Yilmaz framework by analyzing structural changes in spillover networks and decomposing them into frequency components, revealing that global financial spillovers vary significantly across different frequencies, with high-frequency components dominating total spillovers. Moreover, investor sentiment primarily drives short-run spillovers, while the impacts of liquidity and fundamental linkages are more enduring. Our findings indicate that investor sentiment significantly moderates the effects of capital flows and unconventional monetary policies on global spillovers.

This paper highlights several important policy implications. First, regulators should implement real-time sentiment surveillance and early-warning systems to address the role of sentiment in short-horizon contagion.

Second, investors must recognize the systemic importance of markets with strong fundamental and liquidity linkages, as these markets exhibit heightened comovement and are more susceptible to contagion during stress. Additionally, regulators should enhance market-liquidity surveillance to monitor conditions and prevent herding that could trigger liquidity shocks. Finally, proactive expectation-management policies are crucial for mitigating liquidity shocks and reducing the risk of financial contagion.

CRediT authorship contribution statement

Zeyun Bei: Writing – original draft, Software, Formal analysis, Data curation. Liyuan Cui: Methodology, Formal analysis, Conceptualization. Yinggang Zhou: Validation, Supervision, Resources, Project administration, Methodology.

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Data availability

Data will be made available on request.

Appendix A

See Tables A1-A7.

Table A1

Determinants of dynamic changes in spillovers networks using an orthogonalized measure of sentiment.

	Overall			High-frequency			Low-frequency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$SENT^{\perp}$	0.208***		0.176***	0.218***		0.185***	0.068		0.054
	(0.055)		(0.058)	(0.056)		(0.059)	(0.076)		(0.037)
PI		0.736**	0.800**		0.715**	0.778**		0.584**	0.624***
		(0.323)	(0.328)		(0.330)	(0.336)		(0.236)	(0.233)
LIQ		0.279***	0.241***		0.283***	0.245***		0.146***	0.127***
		(0.068)	(0.068)		(0.069)	(0.070)		(0.039)	(0.038)
UMP		0.085	0.081		0.066	0.063		0.170**	0.162**
		(0.076)	(0.074)		(0.075)	(0.073)		(0.070)	(0.069)
TRA		0.142	0.194		0.098	0.155		0.354	0.358
		(0.323)	(0.336)		(0.329)	(0.340)		(0.244)	(0.255)
INT			0.019**			0.019*			0.012***
			(0.010)			(0.010)			(0.004)
GDP			0.066			0.054			0.110*
			(0.059)			(0.061)			(0.060)
$Inflation$			0.001			0.001			−0.001
			(0.003)			(0.003)			(0.002)
$SKEW$			0.012***			0.010***			0.018***
			(0.003)			(0.003)			(0.003)
RET			0.940			1.125			−0.547
			(0.955)			(0.993)			(0.706)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040
Adjusted R^2	0.091	0.091	0.091	0.095	0.095	0.096	0.187	0.187	0.187

Note: This table summarizes the results of the regression (14) with the dependent variables of overall, high-, and low-frequency marginal spillover indices. $SENT^{\perp}_{i\leftarrow j,t}$ is the fundamentals-orthogonalized difference in investor sentiment between market j and i, suggesting the relative optimism of market j against market i that is orthogonal to the fundamental factors. $LIQ_{i\leftarrow j}$ is the difference in market liquidity between markets j and i. $UMP_{i\leftarrow j}$ assesses the disparity in unconventional monetary policies between markets j and i, while $TRA_{i\leftarrow j}$ and $PI_{i\leftarrow j}$ measure the bilateral trade and portfolio investment from market j to market i, respectively, normalized by the total trade and portfolio inflows of market i. Control variables account for differences in GDP, short-term interest rates (denoted as INT), inflation, skewness (denoted as $SKEW$), and returns (denoted as RET) between the markets. The model also includes market-by-market (μ_{ij}) and time-specific (γ_t) fixed effects. We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Standard errors are reported in parentheses below. *,** and *** denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels.

Table A2
Heterogeneity results for sentiment sources using an orthogonalized measure of sentiment.

	Overall			High-frequency			Low-frequency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$SENT^{\perp}_{News}$	0.153***		0.135**	0.161***		0.142**	0.047		0.043
	(0.052)		(0.054)	(0.053)		(0.056)	(0.033)		(0.037)
$SENT^{\perp}_{Social}$		0.109***	0.040		0.115***	0.043		0.030	0.008
		(0.041)	(0.039)		(0.042)	(0.040)		(0.028)	(0.030)
PI	0.803**	0.782**	0.802**	0.782**	0.760**	0.781**	0.625***	0.618***	0.625***
	(0.329)	(0.326)	(0.329)	(0.337)	(0.334)	(0.337)	(0.233)	(0.232)	(0.233)
LIQ	0.244***	0.261***	0.243***	0.247***	0.265***	0.246***	0.128***	0.134***	0.128***
	(0.068)	(0.067)	(0.068)	(0.070)	(0.069)	(0.070)	(0.038)	(0.038)	(0.038)
UMP	0.080	0.080	0.080	0.061	0.062	0.062	0.161**	0.161**	0.161**
	(0.074)	(0.075)	(0.074)	(0.073)	(0.074)	(0.073)	(0.068)	(0.069)	(0.068)
TRA	0.194	0.170	0.193	0.155	0.130	0.154	0.358	0.351	0.358
	(0.335)	(0.336)	(0.335)	(0.339)	(0.341)	(0.340)	(0.255)	(0.253)	(0.255)
INT	0.019**	0.019**	0.019**	0.019*	0.019*	0.019*	0.012***	0.012***	0.012***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)	(0.004)
GDP	0.065	0.067	0.066	0.054	0.055	0.054	0.109*	0.110*	0.109*
	(0.059)	(0.059)	(0.059)	(0.062)	(0.061)	(0.061)	(0.060)	(0.060)	(0.060)
$Inflation$	0.001	0.001	0.001	0.001	0.001	0.001	−0.001	−0.001	−0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
$SKEW$	0.012***	0.012***	0.012***	0.010***	0.010***	0.010***	0.018***	0.018***	0.018***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
RET	0.941	0.937	0.940	1.126	1.122	1.125	−0.547	−0.548	−0.547
	(0.955)	(0.957)	(0.955)	(0.994)	(0.995)	(0.993)	(0.706)	(0.705)	(0.706)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040	142,040
Adjusted R^2	0.091	0.091	0.091	0.096	0.095	0.096	0.187	0.187	0.187

Note: This table summarizes the results of the regression (14) with the dependent variables of overall, high-, and low-frequency marginal spillover indices. $SENT^{\perp}_{news}$ ($SENT^{\perp}_{social}$) is the fundamentals-orthogonalized difference in investor sentiment between markets sourced from news (social media). $LIQ_{i\leftarrow j}$ is the difference in market liquidity between markets j and i. $UMP_{i\leftarrow j}$ assesses the disparity in unconventional monetary policies between markets j and i, while $TRA_{i\leftarrow j}$ and $PI_{i\leftarrow j}$ measure the bilateral trade and portfolio investment from market j to market i, respectively, normalized by the total trade and portfolio inflows of market i. Control variables account for differences in GDP, short-term interest rates (denoted as INT), inflation, skewness (denoted as $SKEW$), and returns (denoted as RET) between the markets. The model also includes market-by-market (μ_{ij}) and time-specific (γ_t) fixed effects. We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Standard errors are reported in parentheses below. *,** and *** denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels.

Table A3
The interaction effect of sentiment and portfolio investment flows using an orthogonalized measure of sentiment.

	Overall		High-frequency		Low-frequency	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: results of the interaction effect of portfolio investment flows on sentiment						
$SENT^{\perp} \times 1\{PI \geq q_{0.75}\}$	0.033	0.037	0.042	0.046	−0.037	−0.036
	(0.123)	(0.121)	(0.128)	(0.126)	(0.098)	(0.068)
$SENT^{\perp}$	0.200***	0.165***	0.207***	0.171***	0.077	0.062
	(0.060)	(0.063)	(0.060)	(0.064)	(0.083)	(0.044)
Adjusted R^2	0.091	0.091	0.095	0.095	0.187	0.187
Panel B: results of the interaction effect of sentiment on portfolio investment flows						
$PI \times 1\{SENT^{\perp} \geq q_{0.75}\}$	0.302**	0.281**	0.329**	0.307**	0.020	0.011
	(0.146)	(0.139)	(0.154)	(0.147)	(0.064)	(0.063)
PI	0.778**	0.746**	0.750**	0.718**	0.649***	0.625***
	(0.320)	(0.319)	(0.328)	(0.326)	(0.230)	(0.232)
Adjusted R^2	0.091	0.091	0.095	0.096	0.187	0.187
Control	No	Yes	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040

Note: Panel A summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of relative optimism ($SENT$) with an indicator $1\{PI \geq q_{0.75}\}$ that equals one if the portfolio investment flow between markets surpasses its 75 % sample quantile and zero otherwise. Panel B summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{SENT \geq q_{0.75}\}$ that equals one if the relative optimism between markets exceeds its 75 % sample quantile and zero otherwise. Other control variables are the same as regression (14). We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Reported are the regression slopes, standard errors in the parentheses, and R^2s. *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels, respectively.

Table A4
The interaction effect of sentiment, portfolio investment flows, and unconventional monetary policy using an orthogonalized measure of sentiment.

	Overall		High-frequency		Low-frequency	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: results of the interaction effect of unconventional monetary policy on portfolio investment flows						
$PI \times 1\{UMP \geq q_{0.75}\}$	0.017	0.007	0.005	−0.006	0.083	0.087
	(0.078)	(0.073)	(0.081)	(0.075)	(0.053)	(0.057)
PI	0.800**	0.799**	0.780**	0.782**	0.616**	0.598**
	(0.327)	(0.320)	(0.334)	(0.327)	(0.239)	(0.235)
Adjusted R^2	0.090	0.091	0.095	0.095	0.187	0.187
Panel B: role of sentiment in the interaction effect of unconventional monetary policy on portfolio investment flows						
$PI \times 1\{UMP \geq q_{0.75}\} \times 1\{SENT^{\perp} \geq q_{0.75}\}$	0.586**	0.561**	0.588**	0.563**	0.346*	0.336*
	(0.270)	(0.262)	(0.274)	(0.265)	(0.181)	(0.182)
$PI \times 1\{UMP \geq q_{0.75}\}$	−0.095	−0.098	−0.107	−0.111	0.017	0.024
	(0.072)	(0.067)	(0.076)	(0.070)	(0.052)	(0.058)
PI	0.893**	0.862**	0.874**	0.844**	0.668***	0.641***
	(0.356)	(0.344)	(0.364)	(0.352)	(0.247)	(0.239)
Adjusted R^2	0.091	0.091	0.095	0.096	0.187	0.187
Control	No	Yes	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142,040	142,040	142,040	142,040	142,040	142,040

Note: Panel A summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{UMP \geq q_{0.75}\}$ that equals one if the gap in unconventional monetary policy between markets surpasses its 75 % sample quantile and zero otherwise. Panel B summarizes the results of the regression of overall, high-, and low-frequency marginal spillover indices on the interaction term of portfolio investment flow (PI) with an indicator $1\{SENT \geq q_{0.75}\} \times 1\{UMP \geq q_{0.75}\}$ that equals one if both the relative optimism and the gaps in unconventional monetary policy between markets exceed their 75 % sample quantile and zero otherwise. Other control variables are the same as regression (14). We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Reported are the regression slopes, standard errors in the parentheses, and R^2s. *, **, and *** indicate significance at the 10 %, 5 %, and 1 % level, respectively.

Table A5
Currency-wise spillover indices.

Rank	Currency		NTS	TS_{out}	TS_{in}	GTS
1	USA	Net Senders	26.494	45.558	19.063	64.621
2	CAN		9.980	23.355	13.375	36.729
3	EUR		6.814	36.870	30.056	66.926
4	GBR		6.057	24.846	18.789	43.636
5	IND		3.145	5.961	2.816	8.777
6	CHN		1.000	1.097	0.097	1.195
7	RUS	Net Receivers	−3.131	6.395	9.526	15.922
8	CHE		−6.348	26.770	33.117	59.887
9	JPN		−7.054	6.565	13.619	20.183
10	KOR		−9.044	3.502	12.547	16.049
11	AUS		−10.072	25.025	35.097	60.122
12	BRA		−17.841	6.538	24.379	30.917

Note: This table summarizes the average time-series currency-wise spillover indices and the ranking of net spillover indices from high to low. The column labeled "TS_{in}" corresponds to the in-strength, as defined in Eq. (4), which quantifies the cumulative spillovers received by the currency of the corresponding row from all other currencies. The column labeled "TS_{out}" corresponds to the out-strength, also specified in Eq. (4), representing the total spillovers transmitted by the currency of the corresponding row to all other currencies. The column labeled "NTS", calculated as the difference between out-strength and in-strength (Eq. 5), represents the net total spillover. The column labeled "GTS", calculated as the summation of out-strength and in-strength (Eq. 6), represents the gross total spillover.

Table A6
Currency-wise spillover indices at different frequencies.

Panel A: high-frequency				Panel B: low-frequency			
Currency (1)	*NTS* (2)	TS_{out} (3)	TS_{in} (4)	Currency (5)	*NTS* (6)	TS_{out} (7)	TS_{in} (8)
USA	24.951	42.897	17.946	USA	1.310	2.273	0.964
CAN	9.009	21.308	12.299	CAN	0.757	1.356	0.598
GBR	5.829	23.280	17.450	EUR	0.553	1.916	1.362
EUR	5.828	34.418	28.591	GBR	0.172	1.175	1.003
IND	3.075	5.515	2.440	IND	0.160	0.413	0.253
CHN	1.091	1.177	0.086	CHN	0.063	0.070	0.007
RUS	−3.102	6.066	9.167	RUS	−0.213	0.407	0.620
CHE	−6.151	25.367	31.518	CHE	−0.229	1.273	1.501
JPN	−6.567	6.597	13.164	AUS	−0.290	1.413	1.703
KOR	−7.492	3.397	10.889	JPN	−0.374	0.273	0.646
AUS	−9.537	22.763	32.300	BRA	−0.913	0.466	1.379
BRA	−16.935	6.049	22.984	KOR	−0.997	0.202	1.199

Note: This table summarizes the average time-series currency-wise frequency spillover indices on the bands corresponding to high-frequency (1–22 days) and low-frequency (above 22 days), which are derived from the spectral representation of volatility spillover network estimated by Eq. (1). "TS_{in}" and "TS_{out}" are currency-wise in-strength and out-strength spillover sequences calculated using the frequency spillover networks with the method specified in Eq. (4). "NTS" is the frequency net total spillover calculated using the frequency spillover networks with the method specified in Eq. (5).

Table A7
Determinants of dynamic changes in currency spillovers networks.

	Overall			High-frequency			Low-frequency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$SENT^{\perp}$	0.060**		0.058**	0.061***		0.058**	0.030		0.030
	(0.024)		(0.023)	(0.023)		(0.023)	(0.028)		(0.028)
TRA		0.771***	0.768***		0.776***	0.773***		0.418**	0.417**
		(0.183)	(0.182)		(0.184)	(0.184)		(0.171)	(0.171)
PI		0.558	0.562		0.562	0.566		0.302	0.304
		(0.388)	(0.389)		(0.391)	(0.391)		(0.308)	(0.308)
UMP		0.042	0.042		0.042	0.042		0.032	0.032
		(0.055)	(0.055)		(0.054)	(0.054)		(0.050)	(0.050)
INT		−0.016	−0.015		−0.016	−0.016		−0.009	−0.009
		(0.013)	(0.013)		(0.013)	(0.013)		(0.012)	(0.012)
GDP		0.037	0.037		0.035	0.034		0.049	0.049
		(0.040)	(0.040)		(0.040)	(0.040)		(0.044)	(0.044)
$Inflation$		0.00001	0.00003		−0.0001	−0.00004		0.001	0.001
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source-Recipient FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	148,097	146,354	146,354	148,097	146,354	146,354	148,097	146,354	146,354
Adjusted R^2	0.009	0.009	0.009	0.009	0.009	0.009	0.034	0.033	0.033

Note: This table summarizes the results of the regression (14) with the dependent variables of overall, high-, and low-frequency marginal currency spillover indices. $SENT_{i\leftarrow j,t}$ is the difference in investor sentiment between economies j and i, suggesting the relative optimism of economy j against economy i. $UMP_{i\leftarrow j}$ assesses the disparity in unconventional monetary policies between economies j and i, while $TRA_{i\leftarrow j}$ and $PI_{i\leftarrow j}$ measure the bilateral trade and portfolio investment from economy j to economy i, respectively, normalized by the total trade and portfolio inflows of economy i. Control variables account for differences in GDP, short-term interest rates (denoted as INT), and inflation. The model also includes economy-by-economy (μ_{ij}) and time-specific (γ_t) fixed effects. We standardize our main dependent variables by subtracting their means and scaling them by their standard deviations. Standard errors are reported in parentheses below. *,** and *** denote rejection of the null hypothesis at the 10 %, 5 % and 1 % levels.

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