



Using AI and Machine Learning to Monitor Financial Markets

Gaston Gelos, Bank for International Settlements

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Can market dysfunction and stressed conditions be predicted in advance?

- A policy-relevant issue:
 - Episodes of market dysfunctions, from periods of sustained illiquidity to fully-fledged financial crises can have substantial economic effects.
- If supervisors could forecast when these episode are most likely to materialize, they could intervene in advance and reduce their severity (or even stop them from happening).

The task is complex

- The ability of econometric models to predict dysfunction and crises out of sample is limited (Fouliard et al, 2021)
- Financial markets are deeply interconnected among themselves and with the real economy
 - Risks can materialise in different ways
 - The system responds to changes implying that propagation channels evolve and are difficult to predict
- Observed episodes of severe financial stress are (thankfully) rare

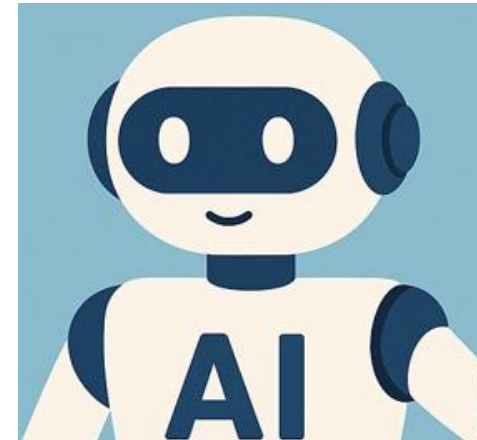
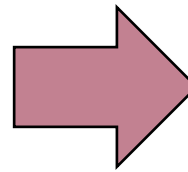
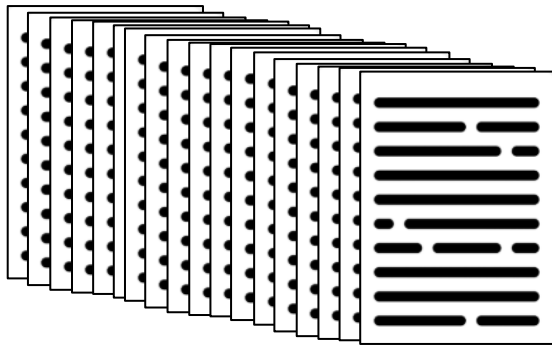
What characteristics should a predictive tool have?

- Two important features:
 1. Ability to predict a wide range of dysfunctions in advance.
 2. Help authorities identify the potential source of future dysfunction
 - Combine ML models with generative AI (LLMs)

How can Generative AI/LLM help financial supervisors?



News articles



AI and ML have significant advantages over traditional econometric models...

- Can easily incorporate nonlinear dynamics
- Use large sets of explanatory variables
- Better-suited to capture rare events
- One drawback is lack of “explainability”...what variable is driving the forecast?

Literature still relatively small & largely focused on asset prices, but growing

- Kelly et al (2023): 'complex' ML model outperform 'simple' econometric ones for stock return predictions. Bali et al (2023): similar result for options.
 - Sirignano and Cont (2019) : deep learning to document that price formation may be driven by similar mechanisms across different types of assets.
- Beutel et al (2019): AI/ML models have poor record of predicting banking crises, while Bluwstein et al (2020) and Tölö (2020) find more positive results for financial crises defined more widely.

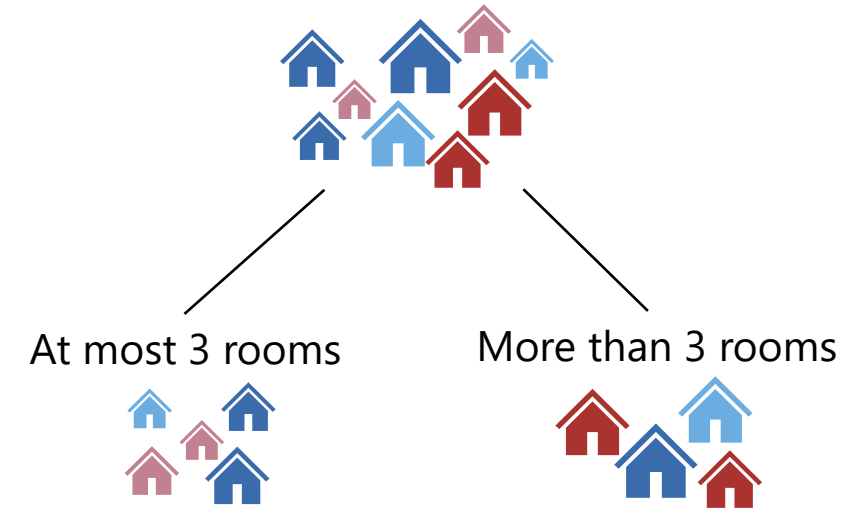
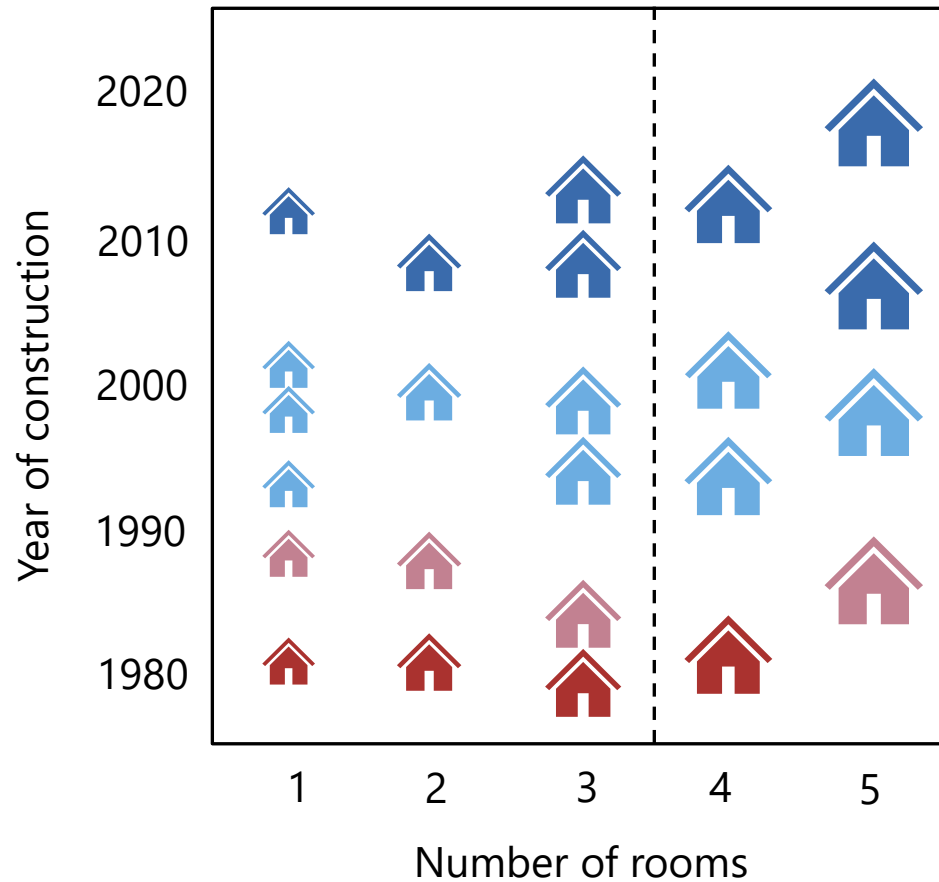
Two approaches developed at the BIS

- Aldasoro, Hördal, Schrimpf and Zhu (March 2025): *Predicting financial market stress with machine learning*. BIS WP 1250.
 - Construct indicators of market conditions and use tree-based ML models to predict the full distribution of their realizations
 - Use Shapley values to produce insights on which variable is responsible for the forecast
- Aquilina, Araujo, Gelos, Park and Perez-Cruz (forthcoming): *Harnessing artificial intelligence for monitoring financial markets*.
 - Demonstrate how recurrent neural networks can predict market dislocations in FX markets
 - Use model-produced weights and LLMs to identify brewing issues potentially causing future dysfunction

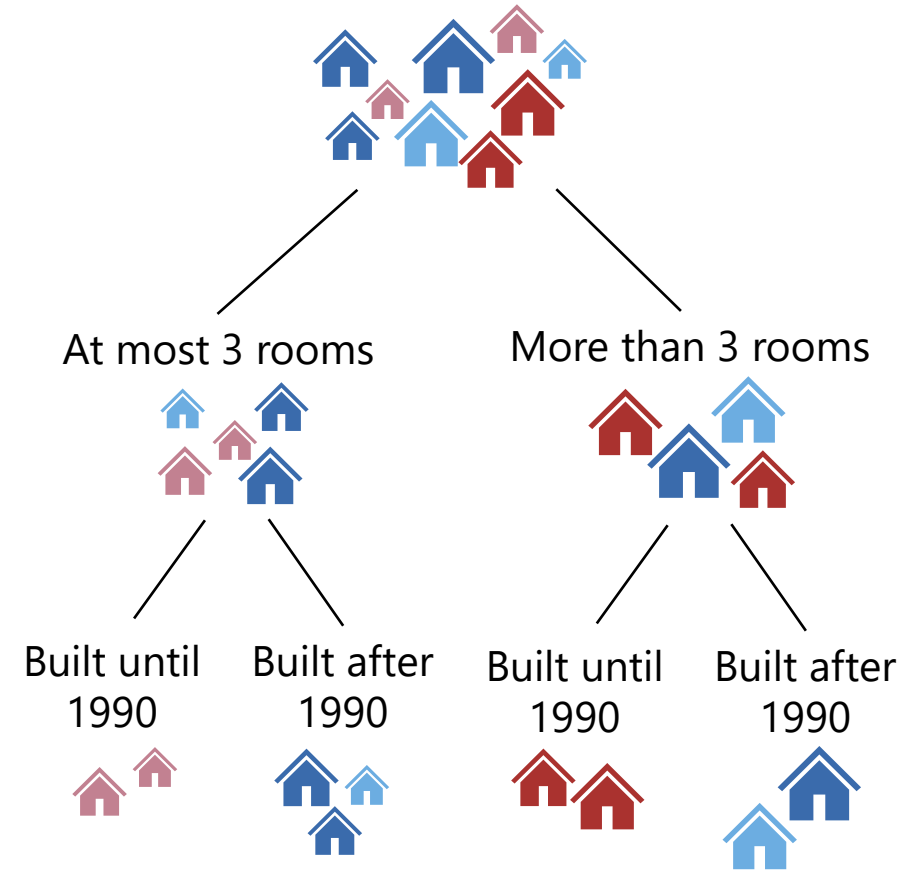
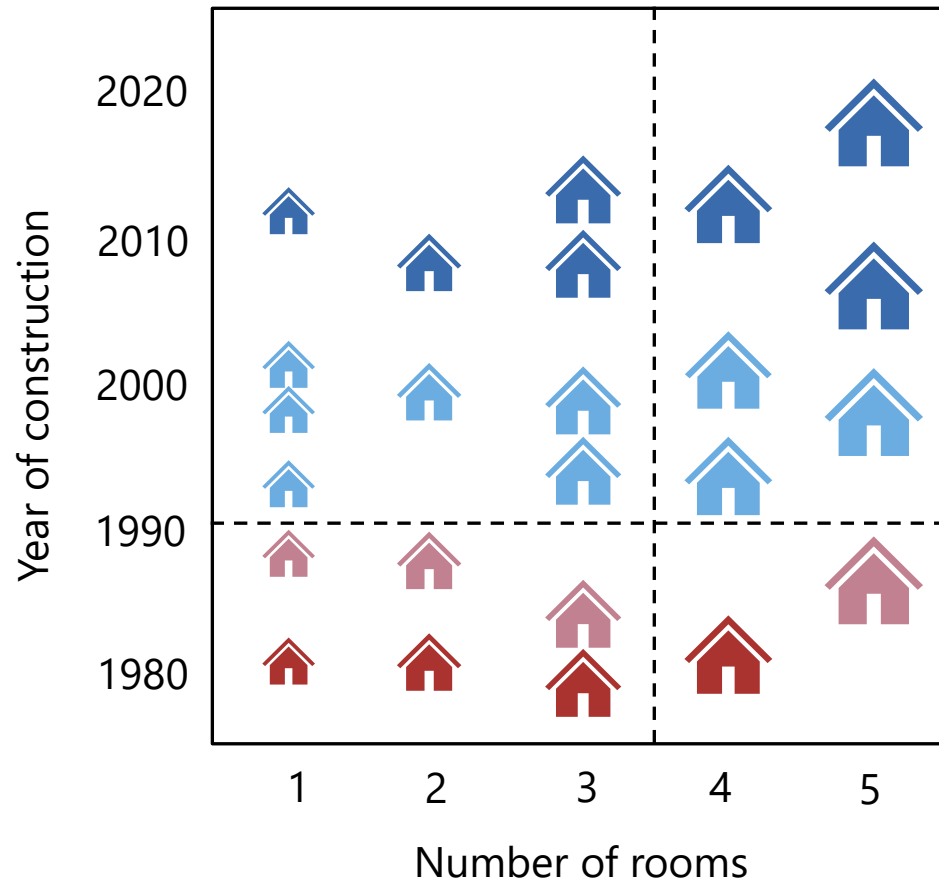
Types of machine learning algorithms used: (i) random forest

- Create independent decision trees for a classification task and generate average predictions of individual trees. By averaging multiple trees, the method reduces the risk of overfitting

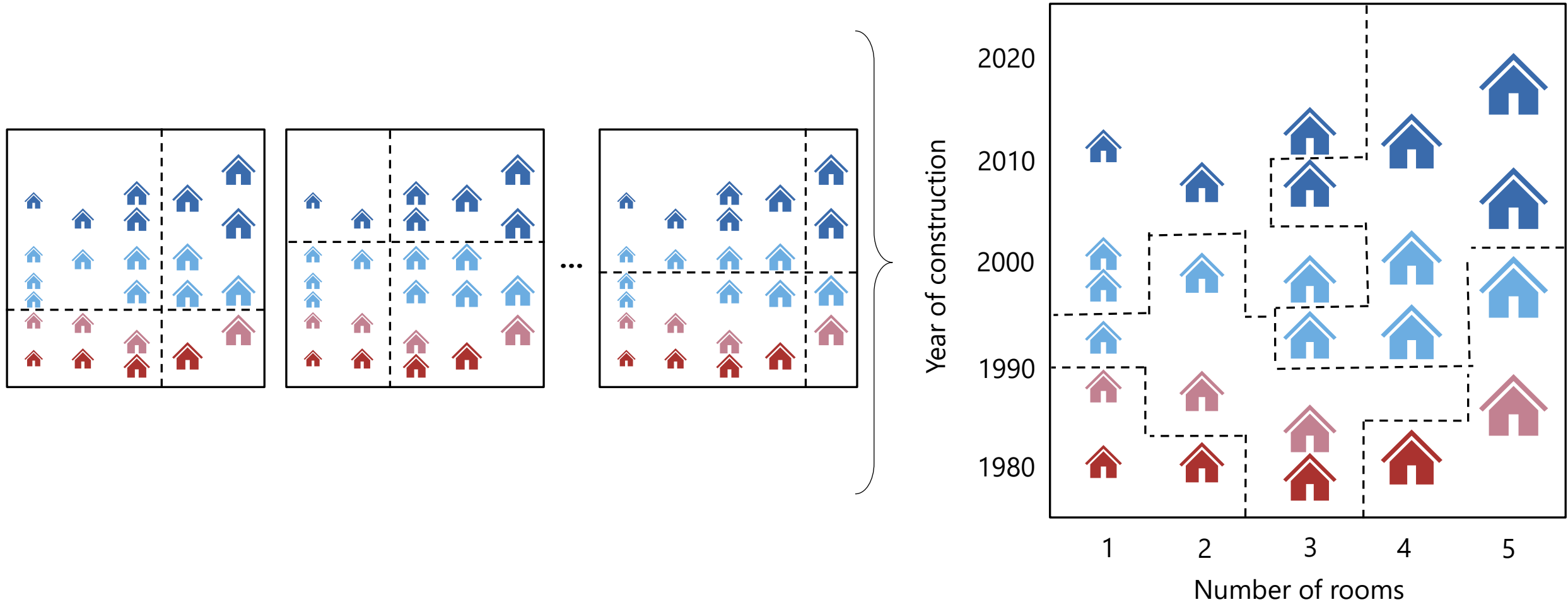
Decision trees group individual data points by sequentially partitioning data into finer categories



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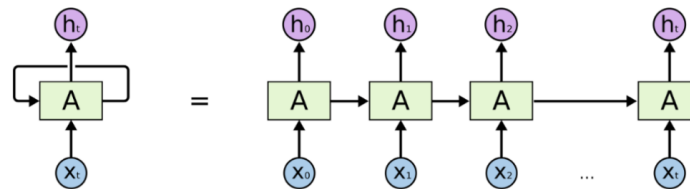


Random forests combine several trees, trained on different slices of the same data, to improve prediction out of sample



Types of machine learning algorithms used: (ii) recurrent neural networks

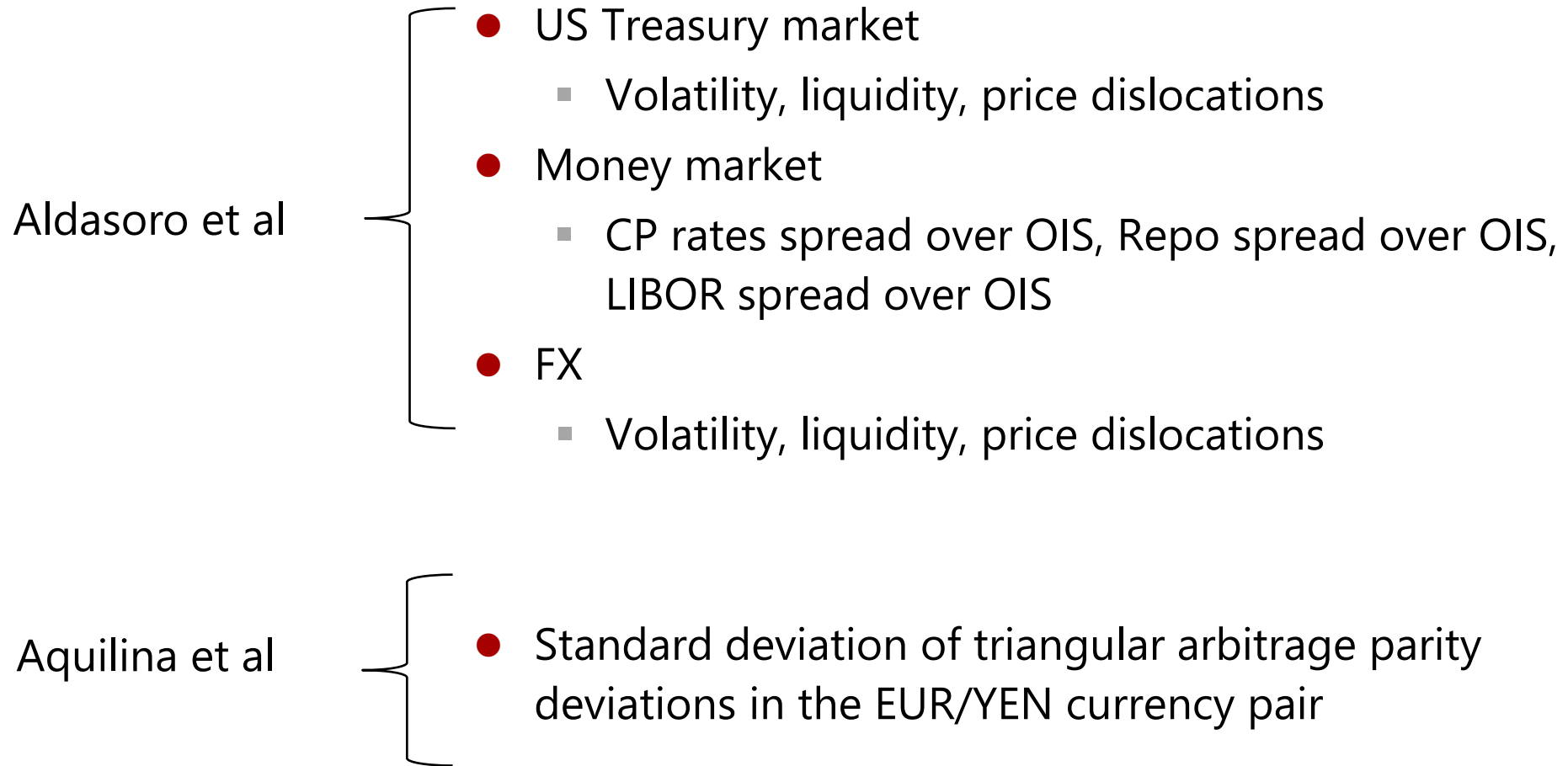
- The architecture is complex, but RNNs function similarly to Kalman filters.
 - The main difference is that relationships between inputs (x) and outputs (h) are nonlinear
 - RNNs take a new input, update their state ("memory"), and produce an output at each time step
- The output of an RNN – the target variable – depends solely on the current input data and on the memory which efficiently stores all relevant information from previous inputs. The RNN also learns nonlinearities flexibly from the data.



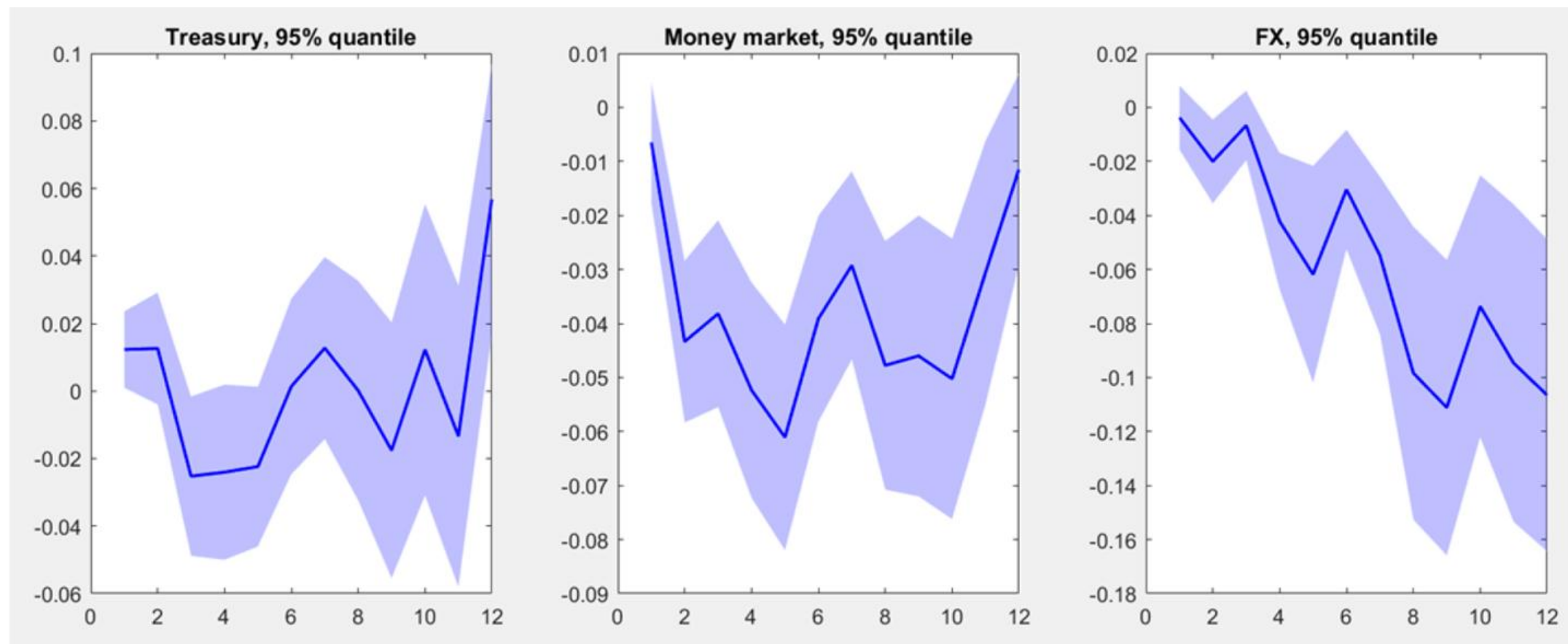
Innovation to RNN architecture: variable weights to explain prediction (Aquilina et al.)

- Add a module to the model that:
 - Uses all the prediction variables
 - Learns the importance of each predictor for the final prediction
 - Updates previous weights to assess current importance of different predictors.
- Useful feature for supervisors and regulators as it gives hints of what is driving the prediction

The two studies use different target variables



Random forests in Aldasoro et al can predict market conditions in money and FX market well, especially at relatively long forecast horizons



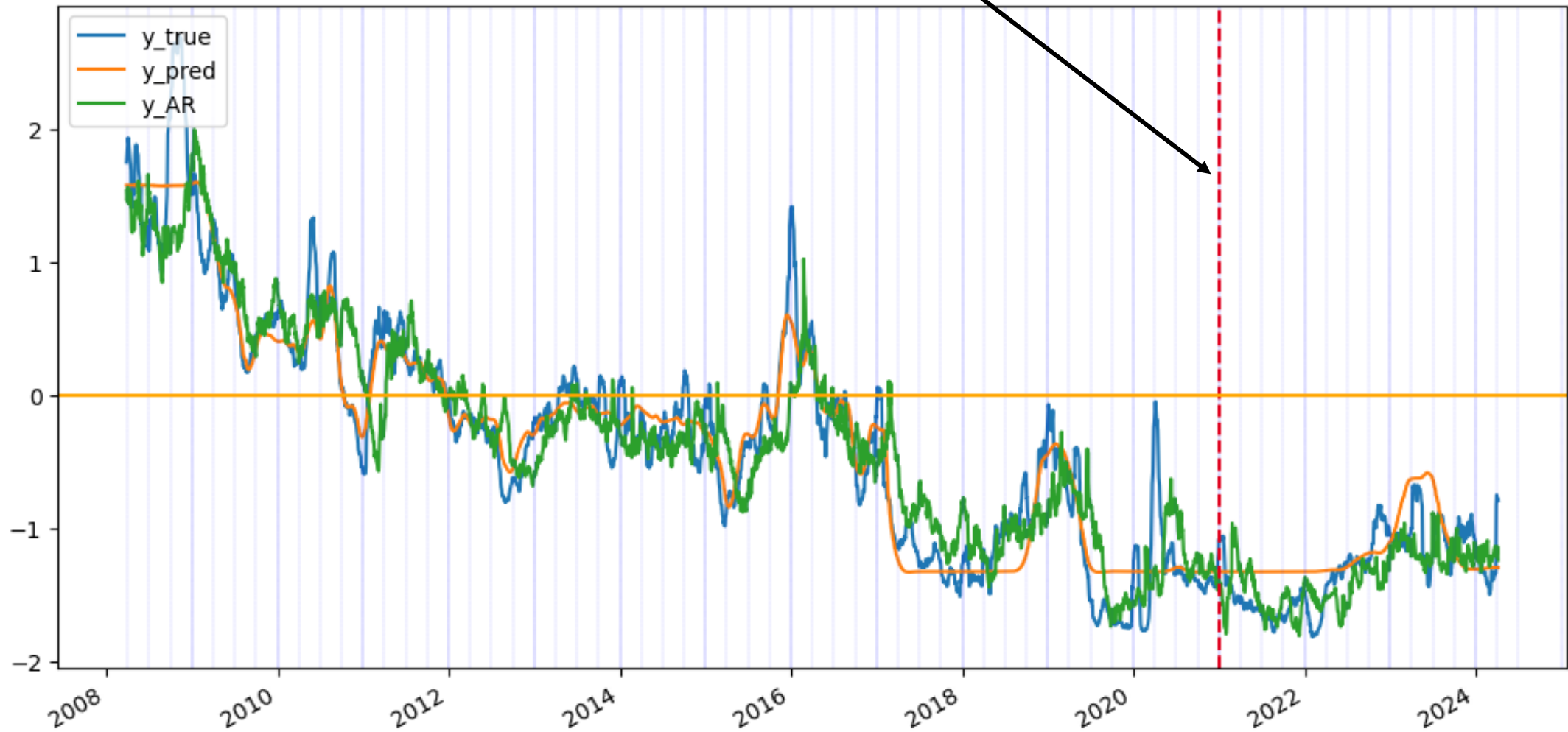
Negative numbers imply RF is better than AR at predicting the 'tail' of the distribution

Violations of triangular arbitrage parity (TAP) as a proxy for market dysfunction (Aquilina et al)

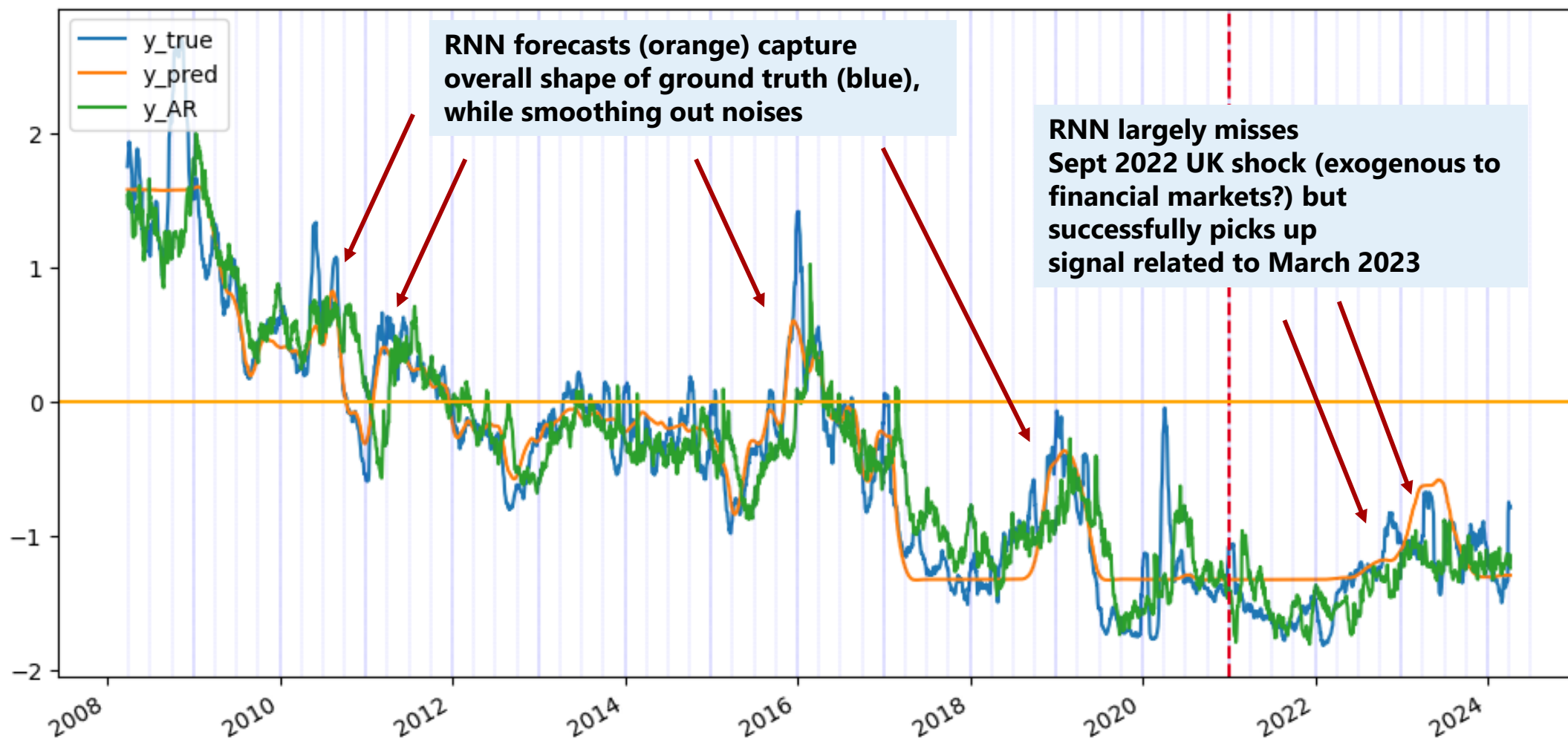
- Example: $\text{EUR/JPY} = \text{EUR/USD} \times \text{USD/JPY}$
 - USD is the “vehicle” currency
- TAP should be easily arbitrated (Lyons and Moore (2009), Pasquariello (2014))
- Focus on TAP violations, ie ‘actual’ minus ‘theoretical’ FX rate
- Our measurement:
 - minute-by-minute TAP violations from LSEG: $\text{EUR/JPY} - (\text{EUR/USD} \times \text{USD/JPY})$
 - aggregated into daily standard deviation

Predicting variance of triangular parity deviations in the EUR-YEN exchange rate

Model training stops in end-2020



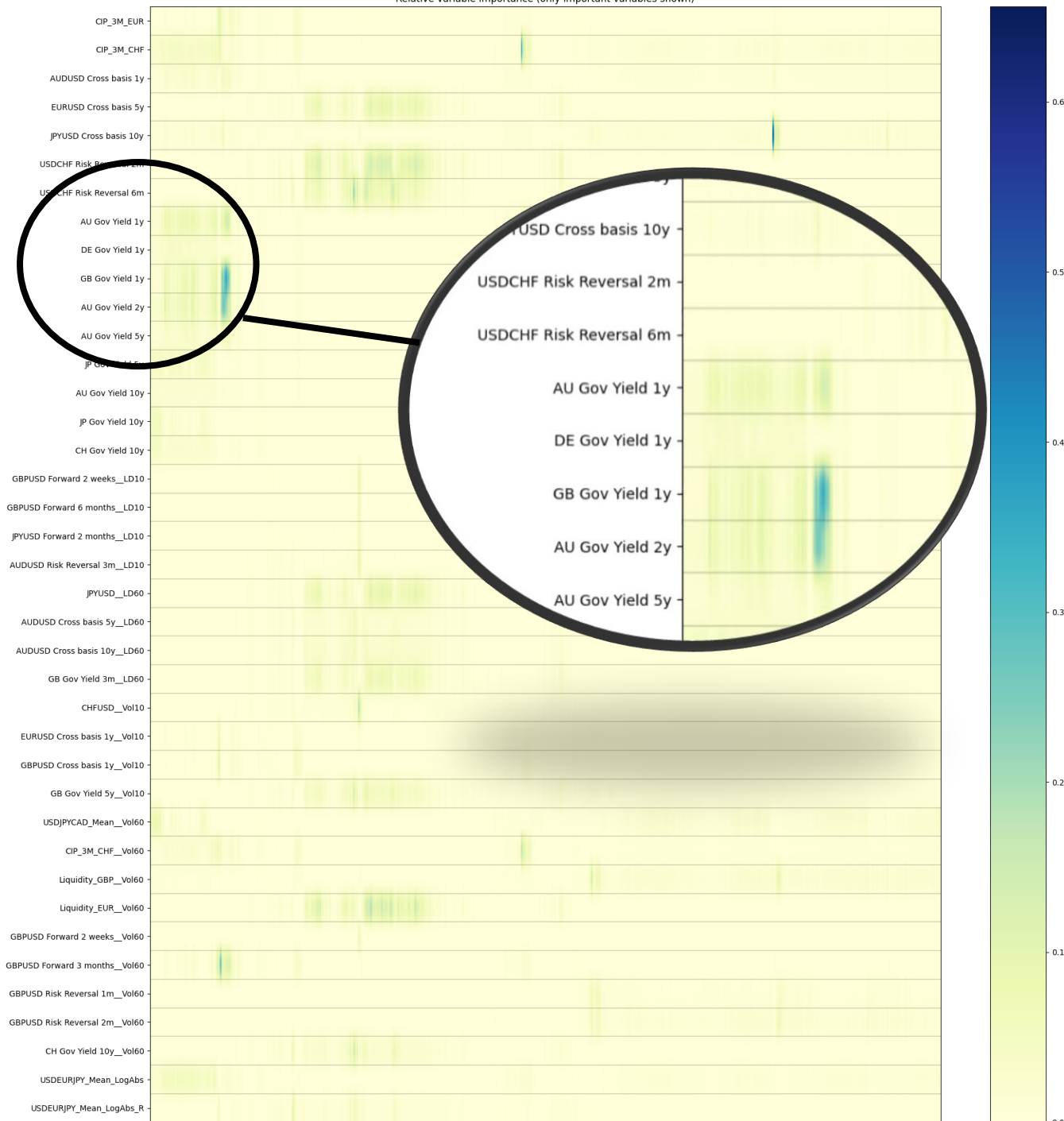
Predicting variance of triangular parity deviations in the EUR-YEN exchange rate



Which variables are driving the forecast?

Aldasoro et al: top predictors for the 90th percentile of FX market conditions using Shapley values

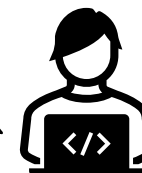
- Shapley values quantify the marginal contribution of each predictor to a specific forecast, conditional on all possible combinations of other variables
- Risk preference and sentiment are important predictors:
 - Implied FX volatility (risk preference)
 - Fund flows (sentiment)



Variable selection by RNN can offer clues for LLMs to search news/reports

1. The RNN learns variable weights
2. At each date, the most important variables are highlighted
3. Armed with the variable names, the model can automatically prompt LLMs

Summarise financial news about [UK and Australia government yield, 1 yr tenor] on this date.



Certainly. Markets reacted strongly to news about

Example: JPY turmoil of 5 August 2024

1 August 2024	2 August 2024
<p>1. US Treasury Yields and Basis Trade Concerns:</p> <p>U.S. Treasury yields experienced a significant drop, with two-year yields falling 17.8 basis points—the largest daily decline since December 2023. This movement is linked to the Fed's potential interest rate cuts and a record volume of basis trades involving Treasury futures and overnight repo markets. The extreme positions in these markets, valued at over \$1 trillion each, pose a substantial risk if unwound suddenly, potentially leading to severe liquidity shortages and market disruptions.</p> <p>The highly leveraged nature of these trades could trigger instability in the broader financial system if market conditions shift abruptly, necessitating close monitoring by supervisory authorities.</p> <p>2. Bank of Japan's Hawkish Stance and Yen Volatility:</p> <p>The Bank of Japan's (BOJ) shift towards a more hawkish policy stance, including potential further rate hikes, has already led to significant volatility in the yen, impacting global carry trades. The BOJ's actions could lead to further strengthening of the yen, disrupting global markets that have heavily relied on the yen as a funding currency.</p> <p>The yen's volatility could trigger a rapid unwinding of carry trades, leading to substantial market fluctuations and liquidity challenges, particularly in emerging markets and other highly leveraged financial sectors.</p> <p>3. Bank of England's Rate Cut and Potential Policy Reversal:</p> <p>The Bank of England (BoE) recently cut interest rates from a 16-year high, signalling a cautious approach to future cuts. This decision reflects growing concerns about the UK economy's resilience and inflation dynamics. The BoE's actions could influence market expectations and create volatility in UK financial assets, with potential spillover effects on global markets.</p> <p>The BoE's policy decisions may impact investor confidence and market stability, especially if future rate cuts or reversals are perceived as insufficient to address underlying economic weaknesses. Monitoring the BoE's communications and market reactions will be crucial.</p>	<p>1. Sharp Decline in U.S. Treasury Yields and Aggressive Rate Cut Expectations:</p> <p>U.S. Treasury yields, particularly the two-year and ten-year, experienced significant drops, with the two-year yield falling below 4% for the first time since May 2023. This decline is driven by weaker-than-expected employment data and increasing market expectations of aggressive interest rate cuts by the Federal Reserve. The market is now pricing in a 120 basis point cut by the end of the year, which could lead to increased volatility and liquidity concerns in the bond market.</p> <p>Sudden shifts in yield curves and rate expectations can cause liquidity strains and lead to disorderly market conditions, particularly if leveraged positions in Treasury futures and overnight repo markets begin to unwind.</p> <p>2. Emerging Markets and Asian Equity Market Volatility:</p> <p>Emerging Asian markets, particularly South Korea and Taiwan, saw significant declines, with indices dropping 4.4% and 3.7% respectively. This sell-off was triggered by fears of a U.S. economic slowdown and was exacerbated by the Fed's potential end to its restrictive policy stance. The broader impact included a significant decline in the MSCI International All Asia Pacific Index.</p> <p>Market volatility in these regions can lead to capital outflows, currency instability, and broader financial instability, which could spill over into other emerging markets and potentially affect global financial stability.</p> <p>3. Increased Bearish Sentiment Among Hedge Funds:</p> <p>Global hedge funds have been increasingly adding bearish bets, particularly in equity markets, driven by fears of a faster-than-anticipated U.S. economic slowdown. This sentiment was reinforced by recent weak economic data, leading to a correction in the Nasdaq Composite and broader equity markets. Hedge funds reduced exposure across multiple sectors, signaling a shift towards a more defensive posture.</p> <p>A continued shift towards bearish sentiment among major financial players could lead to increased market stress and a tightening of liquidity, particularly in riskier asset classes. Supervisory bodies need to monitor these developments to mitigate potential systemic risks.</p>

- Hundreds of daily financial news
- Ask LLM to find most critical news for supervisors *before turmoil*
- LLM successfully identified critical and relevant news

Making AI/ML actionable for financial supervision

- **Real-time market monitoring with explanations**

- Goal is not to build the best-performing crisis forecasting model
- Demonstrate “practical” tools to enhance supervisory monitoring capabilities
- Actionable timeframe for supervisory intervention

- **Opening the “Black Box”**

- Use Shapley values (Aldasoro et al) or a novel approach (Aquilina et al):
 - Adjust NN architecture to weight input vars dynamically for interpretability
 - When dysfunction predicted → identify which variables matter most
 - Feed these key variables to LLMs → retrieve relevant news and context

Conclusions

- AI and ML models highlight promising results for the prediction of episodes of market dysfunction and stress
- BIS analysis show that ML models can forecast dysfunction in different markets such as government bonds and FX
- 'Black box' nature of ML models can be overcome by either using Shapley value or adjusting the architecture of the model to define weights for each variable
- Using LLMs can help supervisors and regulators sift substantial amounts of news and highlight areas of potential concerns.