CITADEL

Automated Decision Systems

Guest Lecturer: John Niccolai

February 2026

CONFIDENTIAL

Introduction

John Niccolai

Chief Operating Officer

Fixed Income & Macro (FI&M)

Career

- Joined Citadel in 2008
  - Chief Operating Officer (2019 – Present)
  - Head of Portfolio Construction (2018 -2019)
  - Head of Quantitative Research (2011 – 2018)
  - Quantitative Researcher (2008 – 2011)
    - Prior to Citadel was at both JP Morgan & Credit Suisse

Education

- Ph.D. in Mathematics from Columbia University
- B.S. Mathematics Caltech

Agenda

- **Section 1 – About Citadel**
  - Citadel
  - Fixed Income & Macro
- **Section 2 – Market Overview**
  - How Does Fixed Income Impact You?
  - News overview / Risk Factor overview / Product overview
  - Government Spending and the Economy
  - FX
  - Mortgages
- **Section 3 – Case Studies**
  - Evaluating trading counterparties
  - Evaluating risk through market simulations
  - Monitoring a live portfolio
- **Section 4 – Roles in the Industry**
- **Section 5 – Q&A**

- **QR Code to connect with our recruiting team:**

CITADEL

The Most Successful Investment Team of All Time

- We strive to identify the highest and best uses of capital.
- We deploy capital to generate superior long-term returns for the world's preeminent public and private institutions.
- We invest in the most promising companies whose innovations improve billions of people's lives.

Our CEO, Ken Griffin

199

0

Founded

$68B

In investment capital as of August 2025

6x

Winner of Multi-strategy Hedge Fund Manager of the Year by Institutional Investor

#1

Most profitable hedge fund manager of all time*

*Edmond de Rothschild estimates, The Top 20 Great Money Managers by Net Gains since inception (after fees) to 31 December 2025. Awarded January 18, 2026.

Citadel – Fixed Income & Macro

Our Fixed Income and Macro strategy seeks to generate alpha in fundamentally driven investments as well as relative value investments.

- Employs a combination of macroeconomic research and analysis, quantitative modeling, and a rigorous investment process to identify and capture opportunities.
- Focuses primarily on investments in the global fixed income and foreign exchange markets.
- Invests in a broad range of investment instruments including sovereign debt, currencies and currency forwards, futures, interest rate swaps, equity indices, options, and other derivatives.

Fast Facts:

- Formed in 2008 – by middle of that year, we had ~12 people
- Several original members are still on the team
- Over the years, we have expanded from trading rates to mortgages, emerging markets, foreign exchange, and more.

Business Head

Edwin Lin

Locations

New York, Greenwich, Miami
London, Paris and Dubai

Team

210+ Investment Professionals

Macro

The macro strategy generally seeks to identify Investment Instruments that are mispriced relative to a range of anticipated economic outcomes.

Relative Value

The relative value strategy generally seeks to minimize direct first order macro-economic exposures, focusing on investing in combinations and/or groups of related Investment Instruments which the Portfolio Manager identifies as being mispriced relative to each other.

Volatility

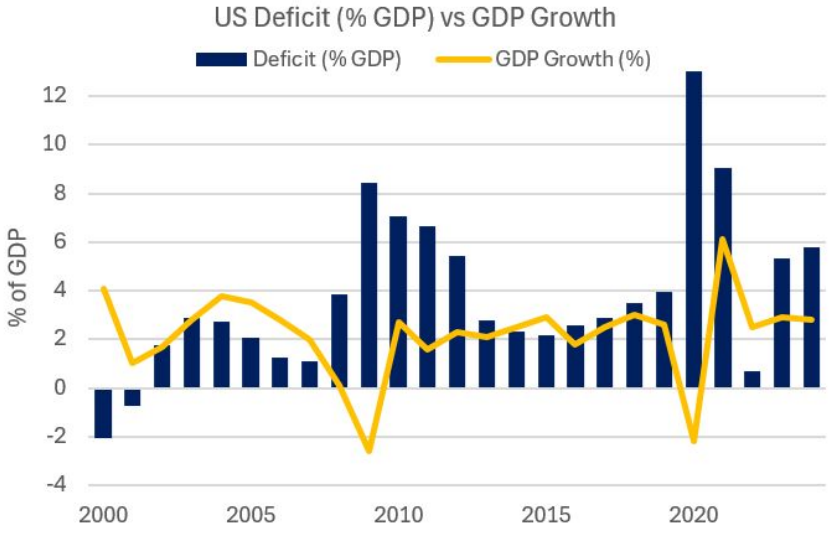
The volatility strategy generally seeks to profit from relative value opportunities in interest rate and FX options using rigorous quantitative analytics and sophisticated risk management techniques.

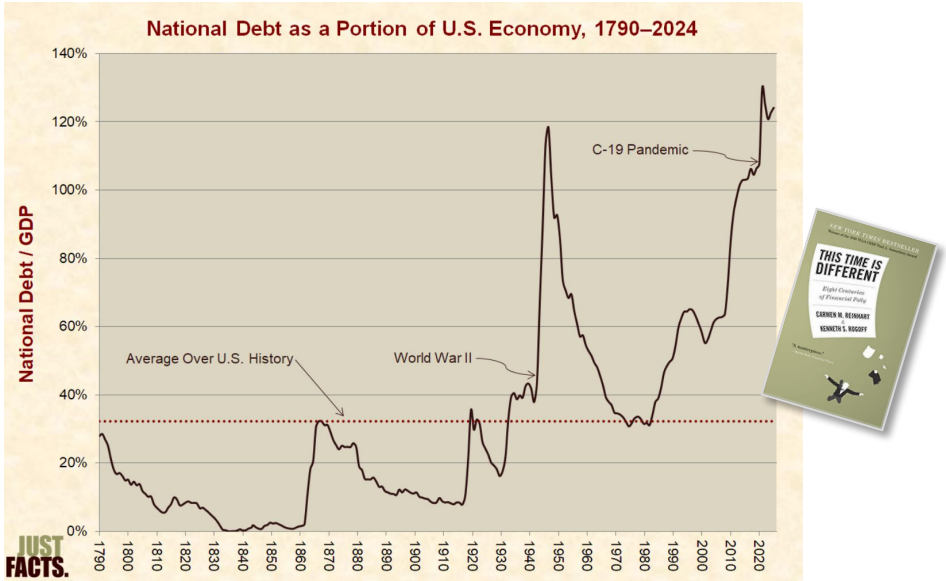
Market Overview

How Does Fixed Income Impact You?

- **Budget Deficits**
- **Monetary & Fiscal Policy**
- **Inflation Pressures**

Some economists believe that things go sideways once **the national debt vs GDP ratio hits 130%...**





News Overview

THE WALL STREET JOURNAL.

English Edition ▾ | Print Edition | Video | Audio | Latest Headlines | Puzzles | More ▾

An Unusually Divided Fed Is Expected to Deliver a Rate Cut

Despite some officials' unease, Chair Jerome Powell appears set to lower interest rates again and signal a higher bar to further easing

By Nick Timiraos Follow

Dec. 9, 2025 5:30 am ET

Share | Resize | 208 | Listen (2 min)

THE WALL STREET JOURNAL.

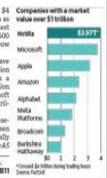
THURSDAY, JULY 10, 2025 - VOL. CCLXXXVI NO. 8 | WSJ.com | ★★★★ $5.00

What's News

Business & Finance

Nvidia Is First to $4 Trillion

Chip maker is at heart of AI boom in gaming, data centers and crypto



Yaccarino Steps Down As CEO of Musk's X

Her departure from the social-media platform follows the merger of xAI and X

The New York Times

Senators Investigate Role of A.I. Data Centers in Rising Electricity Costs

Three Democrats are seeking information from tech firms about the growing energy use of data centers and the utility bills of individuals and other businesses.

"All the News That's Fit to Print"

The New York Times

VOL. CLXXV ... No. 60,754 | SUNDAY, JANUARY 4, 2026 | $6.00

AFTER SEIZING MADURO, TRUMP SAYS U.S. WILL 'RUN' VENEZUELA

Venezuela's largest military complex after explosions in Caracas early Saturday during a strike by U.S. Special Operations forces.

A Raid Caps Off a Monthslong Campaign Against a Leader

Los Angeles Times

TUESDAY, DECEMBER 9, 2025 | latimes.com

Paramount makes a hostile bid for Warner

Proposed takeover by Netflix rival offers $30 per share directly to the stockholders.

By Meg James

Los Angeles Times

MONDAY, DECEMBER 15, 2025 | latimes.com

Mortgage law doesn't help all fire victims

Servicers sometimes deny relief, despite state officials' promises

DESPITE a new state law, the Kendall family of Pacific Palisades was denied 12 months of mortgage relief.

By Laurence Darmiento

Risk Factor Overview

What are the risk factors we look at in Fixed Income and Macro?

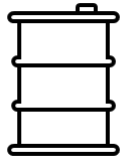
- **Rates**
  - Growth Expectations
  - Central Bank policy (front-end)
  - Liquidity Conditions
  - Flow Dynamics
  - Fiscal Outlook
  - Term Premium Repricing

- **FX**
  - Interest-rate Expectations
  - Policy Divergence
  - De-Dollarization
  - Fiscal Stability
  - Geopolitics

- **Inflation**
  - Growth + Credibility of Policy Responses
  - Supply-Demand Imbalances (Goods, Labor, Energy)
  - Housing
  - Tariffs

- **Equity**
  - Global Risk Appetite
  - Earnings, Margins
  - Investor Positioning
  - Regulation
  - AI

- **Commodity**
  - Supply Constraints
  - Geopolitical Risk
  - Global Demand
  - Transport
  - Weather



Product Overview: What products let us trade these risk factors?

The categories below broadly describe what a liquid fixed income and macro fund will trade

Listed Products

- Listed on public exchange on limit order book (CLOB)
- Trade mechanics: Participants submit bids/offers electronically to the order book, where matching follows price-time priority

Listed Futures & Options

Equity Indices

Currencies

- Value of one currency in terms of another
- Trade mechanics: Executed mainly on electronic Over-the-Counter (OTC) platforms or via bank dealers providing streaming quotes

~ 30 unique currencies

Cross Currency

~110 vol currency pairs

Over The Counter (OTC)

- Bilateral contract between two counterparties
- Lacks the level of transparency of listed products
- Trade mechanics: Terms negotiated with dealers or via electronic requests for quotes (RFQs), then confirmed and cleared

OTC Options

Inflation

Swap

Securities

- Issued by an entity e.g. a government
- Has a unique identifier (CUSIP)
- Wide range of liquidity profiles

Mortgages

Bonds

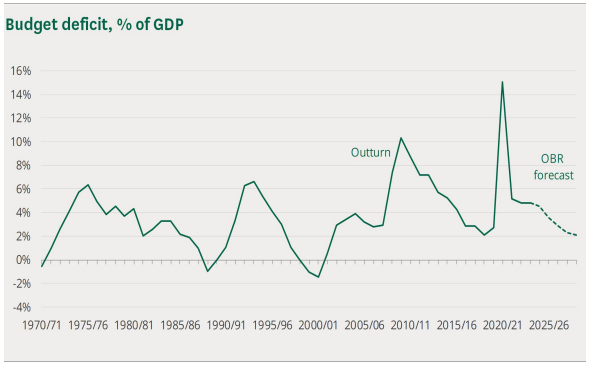
Options available across all these categories

Market Overview – Government Spending & the Economy

The UK, France & the US – Political complications

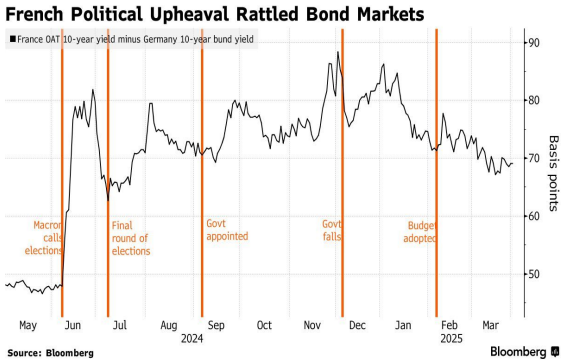
The UK

- Budget Deficit: ~5 %
- Debt/GDP: ~95-97 %
- Recently in the news: “UK budget beat lacks a long-term lift”



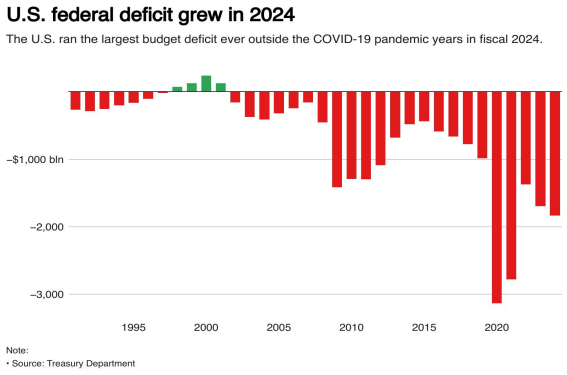
France

- Budget Deficit: ~5-6 %, well above EU targets
- Debt/GDP: ~114-118 %
- Recently in the news: “65-year-old retirees in France now have higher incomes than working-age adults”



The US

- Budget Deficit: ~6 %
- Debt/GDP: ~100 % and rising
- Recently in the news: “The trust funds for Social Security and Medicaid will run out of money in as little as 8 years”

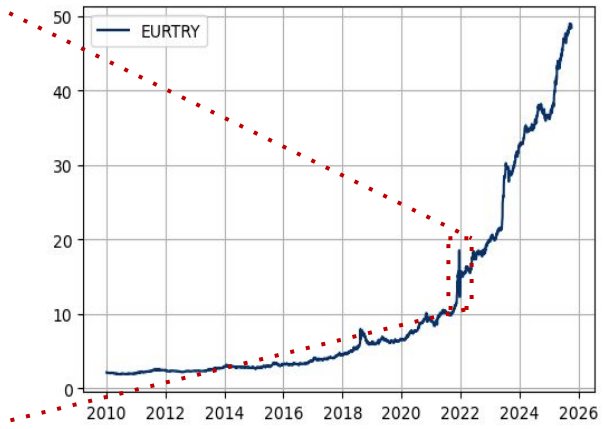


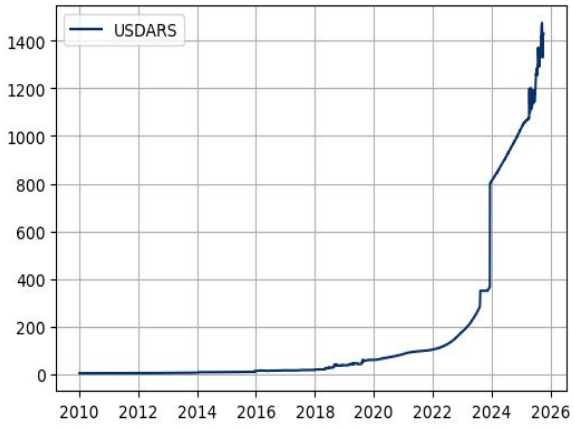
Market Overview – FX in Developed Markets

- Generally, developed market currency pairs are expected to be relatively stable (not expected to be move more than 1-2% in a day), reflecting deep liquidity and well-anchored monetary frameworks
- However, in 2015, the Swiss franc rallied ~30% relative to the euro after the Swiss National Bank removed its currency peg against the euro
- This marked one of the largest DM FX shocks on record and a reminder that policy regime changes can overwhelm normal market dynamics

Market Overview – FX in Emerging Markets

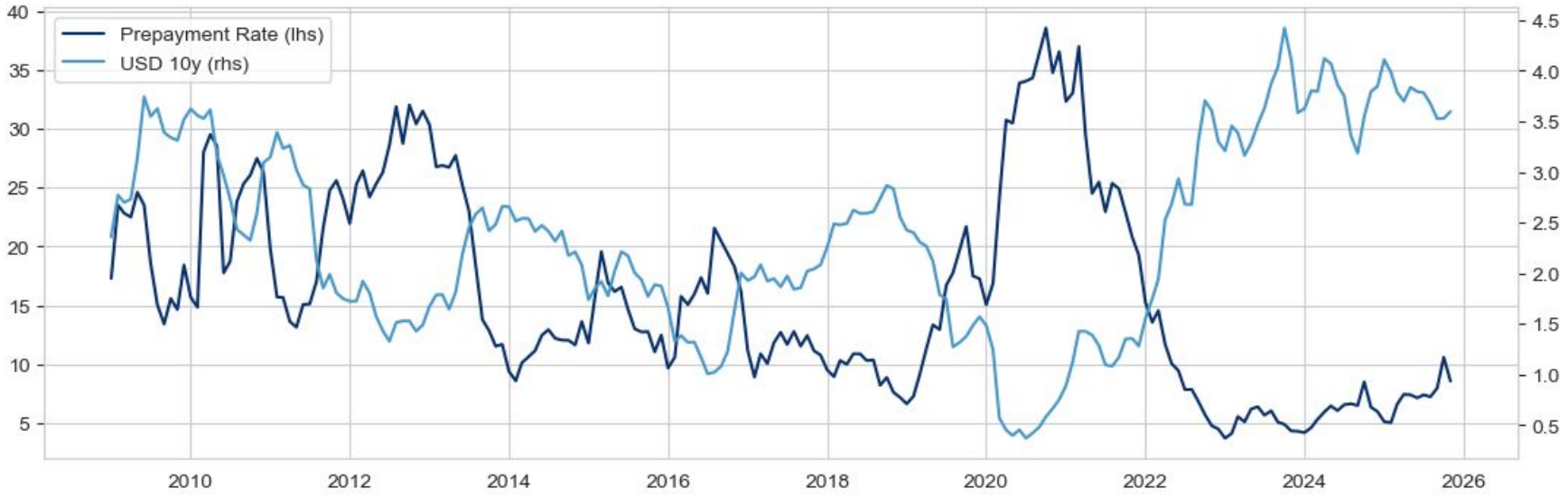
- In contrast to developed markets, emerging market currencies are structurally more volatile, reflecting:
  - Thinner liquidity
  - Higher inflation
  - Weaker policy anchors
- Over the past decade, currencies such as the Turkish lira (TRY) and Argentine peso (ARS) have seen sustained depreciation driven by macro imbalances and policy intervention





Market Overview – Mortgages

- US homebuyers have shown a desire for security with a consistent payment, so banks issue a fixed rate mortgage
  - When interest rates fall, mortgage borrowers can refinance at a lower rate or pay off larger parts of their mortgage
  - When interest rates rise, mortgage borrowers are disincentivized to refinance/prepay
  - Notice the homeowner has an embedded option



Market Overview – Mortgages

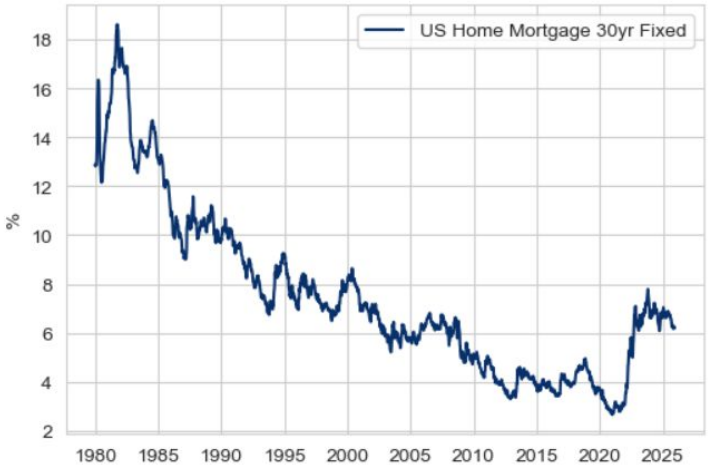
How do Mortgage Rates Influence Monthly Payments?

Median US Home Price**: $415,200
3% interest rate: $1,400
6% interest rate: $1,991
15% interest rate: $4,200

Outstanding Mortgages in the US

85 million ($13.1 trillion)
(as of Q2 2025)

Mortgage Rates 1980 - 2025

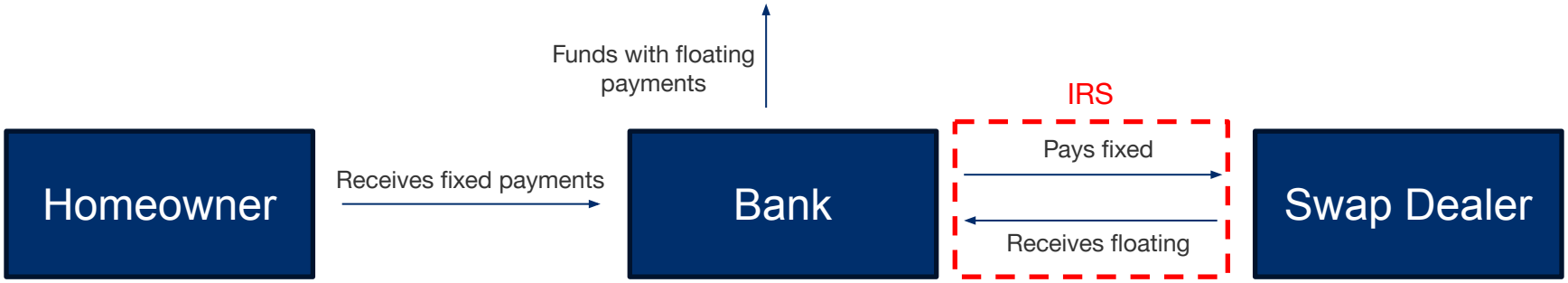


Mortgage Rates 2012 - 2025

*Source: LendingTree
**Source: BankRate

Market Overview – Mortgages

- Bank issues fixed-rate mortgages, but fund their liabilities at floating rates



- **Recall the homeowner has acquired an option on interest rates embedded in their mortgage loan**
  - This leads the bank to leveraging the swaption market to hedge this complex exposure

Case Studies

Evaluating Trading Counterparties

Case Study #1

Evaluating Trading Counterparties

Case Study #2

Evaluating risk through market simulations

Case Study #3

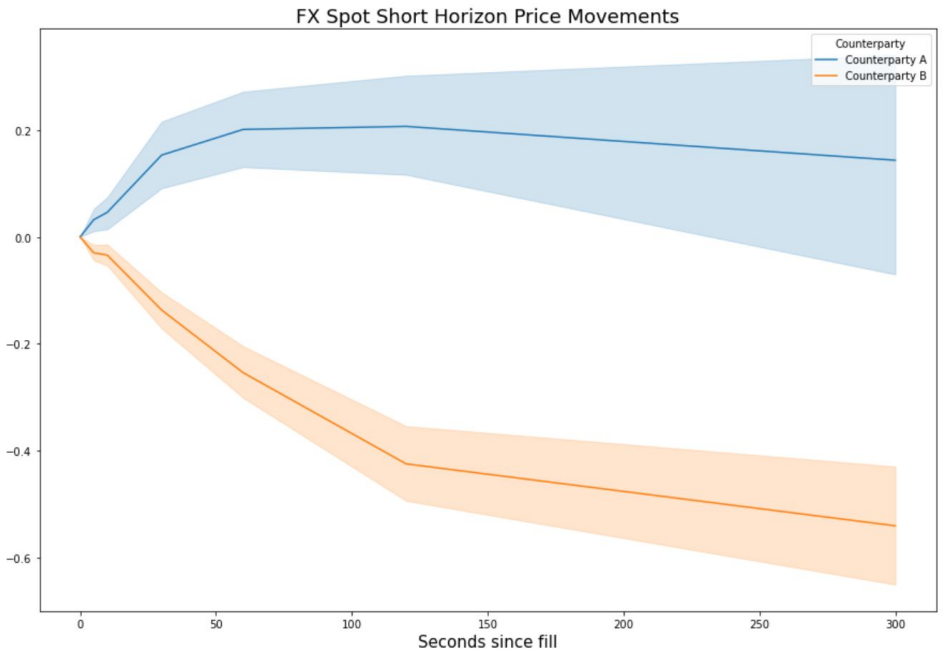
Monitoring a Live Portfolio

Pricing the Trade?

- Who generally has the best price or the tightest/most consistent pricing?
- How does the price change after executing with each counterparty?
- Resources – What resources do they extend?
- Transaction Cost – How much does it cost to do the trade?
- Market Impact - How does the price of the trade change post execution?

How Many Counterparties?

- More counterparties increases likelihood of finding the lowest price but increases information leakage
- Counterparties may change their pricing based on how many dealers they are in competition with
- We trade in a dynamic environment – Dealers may respond aggressively when losing market share



Evaluating risk through market simulations

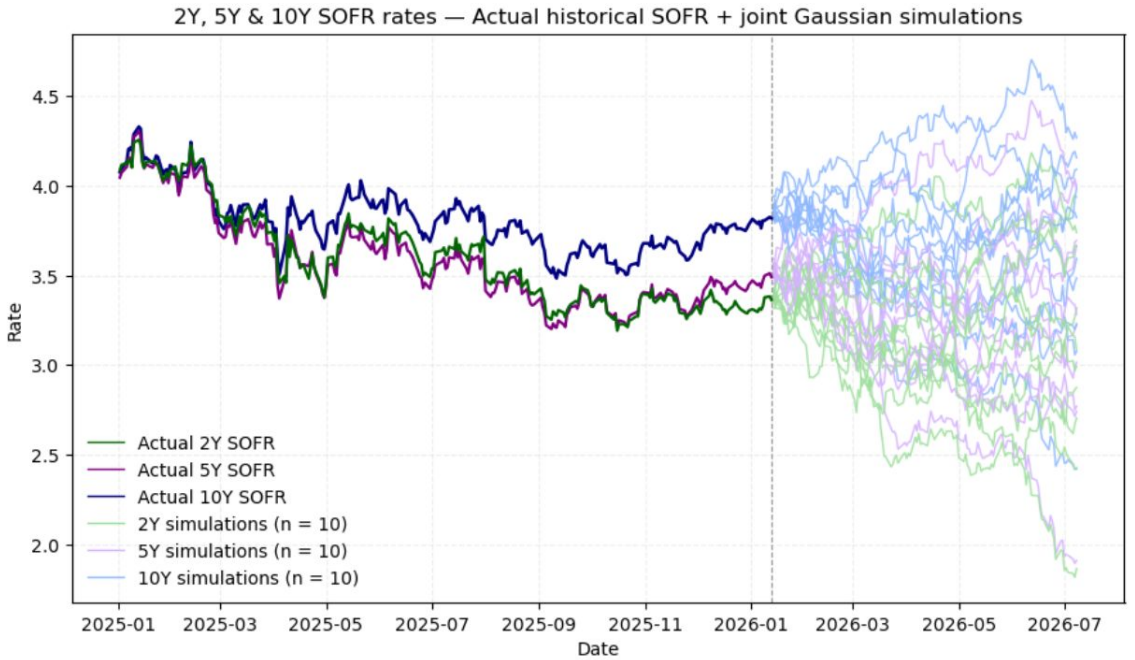
Case Study #1
Evaluating Trading Counterparties

Case Study #2
Evaluating risk through market simulations

Case Study #3
Monitoring a Live Portfolio

- Common Baseline: Gaussian market simulations
  - Variances and correlations estimated from historical data
  - Variance scales linearly with time
  - Simple, intuitive, computationally efficient
  - Dependence captured via **constant correlation matrix**

	2y	5y	10y
2y	1.00	0.95	0.86
5y	0.95	1.00	0.97
10y	0.86	0.97	1.00



Note: Variances and correlations are calibrated from actual data; the mean of rate changes is set to zero for all simulated paths.

- What could go wrong?

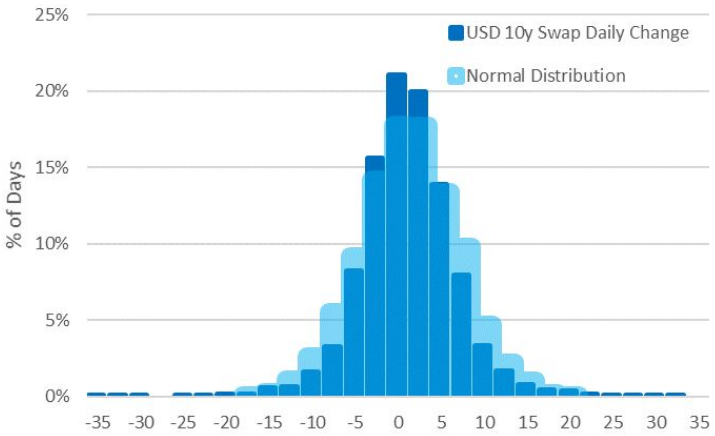
Evaluating risk through market simulations

Case Study #1
Evaluating Trading Counterparties

Case Study #2
Evaluating risk through market simulations

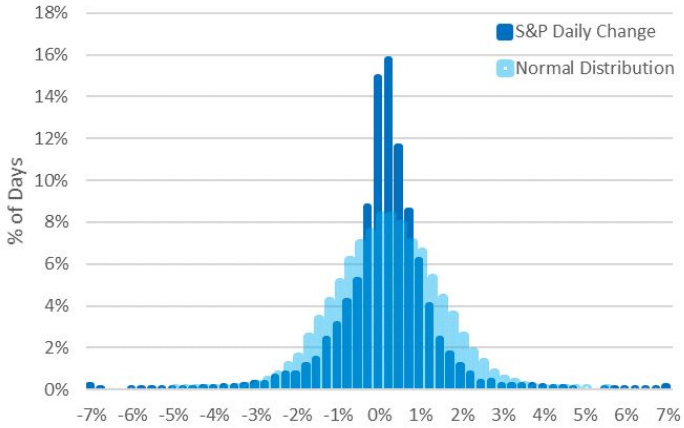
Case Study #3
Monitoring a Live Portfolio

- Tails and skew — Real markets are not Gaussian
  - Empirical distributions exhibit:
    - Fat tails: more extreme moves than normal
    - Skew: asymmetric upside vs downside risk



Example 1: USD 10Y swap absolute daily moves plotted with a normal distribution with the same mean and standard deviation (-0.06 bps and std 5.6 bps)

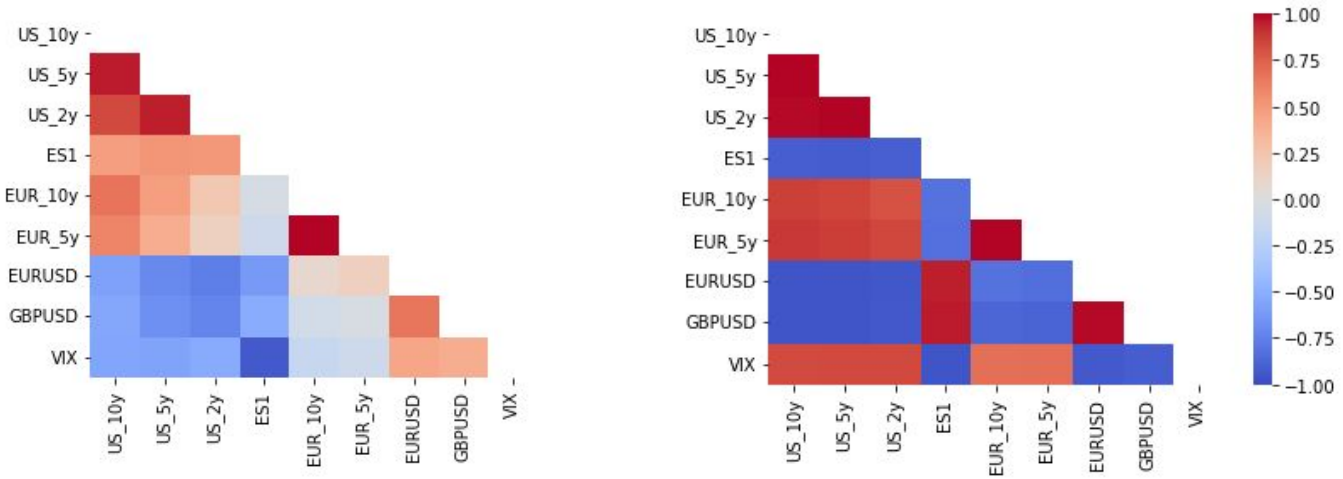
Example 2: S&P relative daily moves plotted next to a normal distribution with the same mean and standard deviation (mean 0.03 pp and std 1.22 pp)



Evaluating risk through market simulations

- Correlation is unstable
  - Linear correlation captures average co-movement but misses **tail dependence**
  - Correlations are:
    - Time-varying / Regime-dependent
    - Typically higher in stress: Risk concentrates when assets fail together

2018 → 2023



Evaluating risk through market simulations

- What needs to be calculated
  - Want at least 18 years of market data (through the 2008 Global Financial Crisis)
  - Trade all major stock indices
  - Trade yield curves in over 20 countries
  - Trade bond curves in over 20 countries
  - With 45 currencies, possibility to trade 45 choose 2 (=990!) currency pairs
  - 10,000+ listed SOFR future options, of which 1,600+ are actively traded
  - Thousands of listed sovereign bonds

USD/US | EUR/GR | EUR/FP | EUR/IM | EUR/SM | EUR/BB | EUR/FH | GBP/UK | JPY/JP | AUD/AU | CAD/CN | MXN/MM | TRY/TI

2Y | 3Y | 5Y | 7Y | 10Y | 20Y | 30Y | Cpn to | FreeFloat to | YearFrac to

Short Code	Sec	Issue Date	Coupon	Yr Frac	DV01	Dur	Cvx	Cvx Bps	Prv Cvx	Cvx CoD	Rlzd Vo	Bond Tag	Free Float
usaug26_2y	2Y	2024-09-03	3.750%	0.61	0.59	0.58	0.01	0.14	0.01	0.00	30.78		68.23
ussep26_2y	2Y	2024-09-30	3.500%	0.69	0.67	0.67	0.01	0.15	0.01	0.00	29.48	O4 1Y	69.00
usoct26_2y	2Y	2024-10-31	4.125%	0.77	0.76	0.75	0.01	0.16	0.01	0.00	34.34	O3 1Y	68.99
usnov26_2y	2Y	2024-12-02	4.250%	0.86	0.84	0.83	0.01	0.17	0.01	0.00	32.15	O2 1Y	66.68
usdec26_2y	2Y	2024-12-31	4.250%	0.94	0.92	0.91	0.01	0.18	0.01	0.00	34.00	O 1Y	68.99
usjan27_2y	**2Y**	**2025-01-31**	**4.125%**	**1.03**	**1.00**	**0.98**	**0.01**	**0.19**	**0.01**	**0.00**	**37.21**	**1Y**	**68.94**
usfeb27_2y	2Y	2025-02-28	4.125%	1.10	1.08	1.05	0.02	0.20	0.02	0.00	38.48		68.92
usmar27_2y	2Y	2025-03-31	3.875%	1.19	1.16	1.14	0.02	0.21	0.02	0.00	40.13		68.74
usapr27_2y	2Y	2025-04-30	3.750%	1.27	1.23	1.22	0.02	0.22	0.02	0.00	42.10		68.99
usmay27_2y	2Y	2025-06-02	3.875%	1.36	1.32	1.30	0.02	0.23	0.02	0.00	42.72		68.90
usjun27_2y	2Y	2025-06-30	3.750%	1.44	1.39	1.39	0.03	0.24	0.03	0.00	43.37		69.00
usjul27_2y	2Y	2025-07-31	3.875%	1.52	1.48	1.44	0.03	0.25	0.03	0.00	44.43		69.00
usaug27_2y	2Y	2025-09-02	3.625%	1.61	1.55	1.52	0.03	0.26	0.03	0.00	44.99	O4 2Y	69.00
ussep27_2y	2Y	2025-09-30	3.500%	1.69	1.62	1.61	0.03	0.27	0.03	0.00	45.35	O3 2Y	69.00
usoct27_2y	2Y	2025-10-31	3.500%	1.77	1.70	1.69	0.04	0.28	0.04	0.00		O2 2Y	69.00
usnov27_2y	2Y	2025-12-01	3.375%	1.86	1.78	1.77	0.04	0.29	0.04	0.00		O 2Y	69.00
usdec27_2y	**2Y**	**2025-12-31**	**3.375%**	**1.94**	**1.85**	**1.86**	**0.04**	**0.30**	**0.04**	**0.00**		**2Y**	**69.00**

  - Portfolio may have tens of thousands of trades
  - Requires memory-efficient data structures, a lot of compute, parallelization…

Monitoring a Live Portfolio

Case Study #1

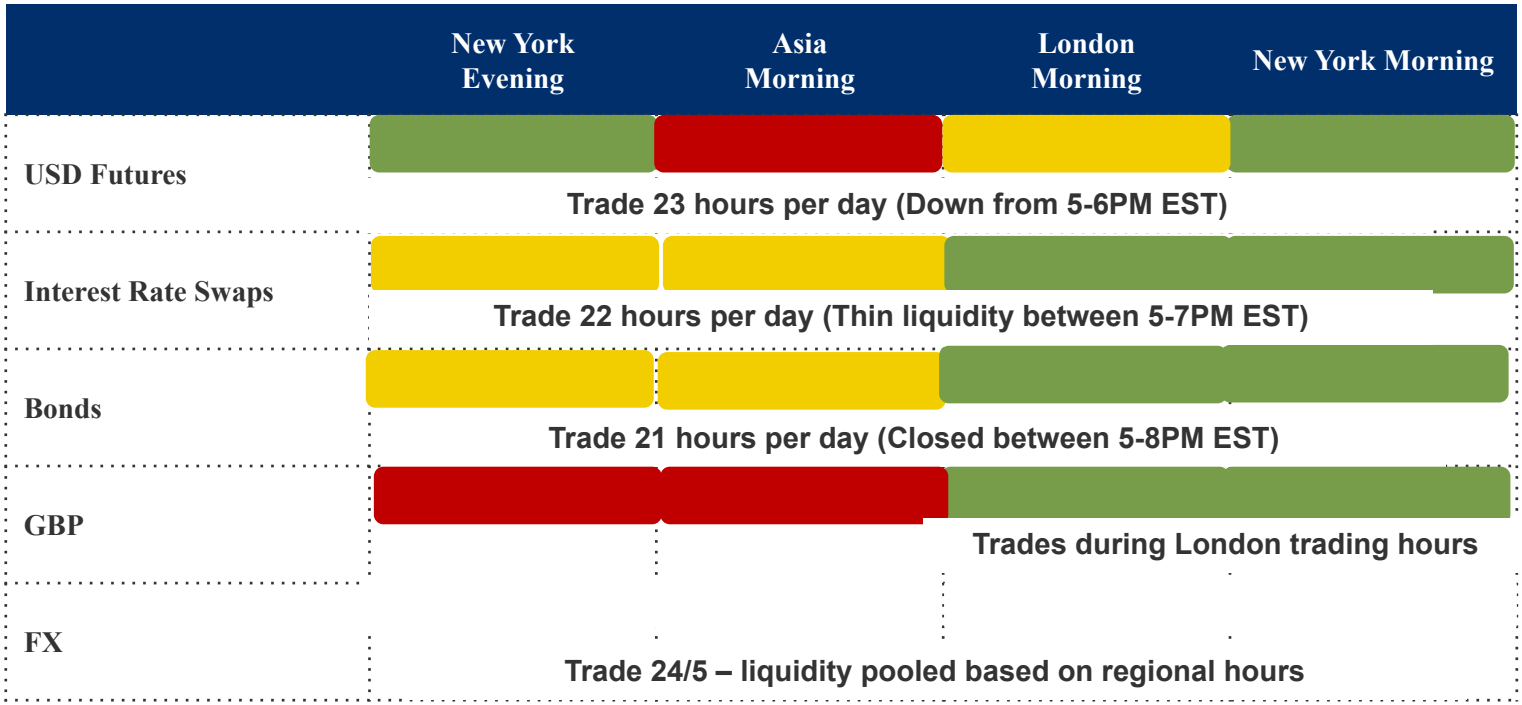
Evaluating Trading Counterparties

Case Study #2

Evaluating risk through market simulations

Case Study #3

Monitoring a Live Portfolio



Monitoring a Live Portfolio

Case Study #1

Evaluating Trading Counterparties

Case Study #2

Evaluating risk through market simulations

Case Study #3

Monitoring a Live Portfolio

- **Price feeds for many bonds can have gaps between ticks**
  - This introduces inaccuracies in pricing models, strategy development, execution etc.
  - Example (5y Treasuries): The yield on the 7y off-the-run US bond (adjusted +2.5 bp) tracks the yield on the on-the-run 5y bond but updates less frequently

- **Things to Consider:**
  - Fast/robust inference for stale bond prices using ticks from frequent bonds?
  - How do you distinguish truly idiosyncratic relative movements between frequent and infrequent bonds?

Technology Roles

Roles in Industry

Citadel's Campus Recruiting team seeks talent across a variety of quantitative and technology focused roles

	Risk Taking	Financial Math	Coding	Project Management
Trading				
Quantitative Research				
Quantitative Strategist				
Business Analyst				
Quantitative Developer				
Software Engineer				

Q&A

QR Code to connect with our recruiting team:

IMPORTANT NOTICE

This presentation is for the internal use of the recipient(s) only and not for redistribution to potential investors or an offer or solicitation with respect to any securities. Any offer of securities can only be made by a current Confidential Offering Memorandum, which is available on an exclusively private basis and only to qualified financially sophisticated investors. Nothing in this presentation constitutes investment, tax, legal or other advice, and the information contained herein does not purport to represent any investment strategy or product of Citadel.

The information contained in this document is current only as of the date indicated. Citadel has no obligation to update the information following such date and no recipient of the information should rely on such information as current, accurate or complete following such date.