

# The "Dollar Smile"

## A Quantitative Analysis of USD Regimes and Their Impact on Cross-Asset Performance

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### ABSTRACT

This study provides a comprehensive quantitative framework for testing the "Dollar Smile" theory, which says that the U.S. Dollar strengthens during both periods of strong and weak U.S. economic growth. Using 2020-2024 market data, I developed a rule-based regime classification system based on VIX volatility levels and DXY 50-day rate of change. My analysis of three key asset classes (SPY, EEM, GLD) across four distinct regimes validates core predictions of the Dollar Smile theory. Emerging market equities (EEM) underperformed dramatically during Risk-Off Dollar Strength periods (-48.9% annualized vs -22.1% for SPY) and outperformed during Dollar Weakness periods (+35.1% vs +28.1% for SPY). Statistical significance testing confirmed meaningful regime differences for emerging markets ( $p=0.047$ ). The results provide actionable insights for asset allocation and risk management strategies.

### CCS CONCEPTS

- Information Systems -> Data Mining
- Applied Computing -> Economics
- Computing methodologies -> Modeling and Simulation

### KEYWORDS

Data Mining, Financial Markets, Time Series Analysis, Regime Detection, U.S. Dollar, Asset Allocation, Volatility.

### ACM Reference format:

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### 1 PROBLEM STATEMENT AND MOTIVATION

The U.S. Dollar is the world's primary reserve currency, and its fluctuations have profound implications for global financial markets. The "Dollar Smile" theory, popularized by economists at Morgan Stanley, provides an intuitive model for understanding USD behavior. It suggests the dollar appreciates on the left side of the "smile" during global risk-off events (a flight to safety) and on the right side during periods of strong U.S. economic outperformance (a flight to quality/growth). In the middle, the dollar is presumed to be weaker.

While this theory is widely cited, its regimes are not always clearly defined. The motivation for this project is to move beyond qualitative descriptions and develop a data-driven method for identifying these dollar-defined regimes. The knowledge gained will address three central questions:

1. Can we quantitatively define and historically identify distinct market

regimes based on the strength and volatility of the USD?

2. How do different asset classes, specifically U.S. equities (SPY), emerging market equities (EEM), and gold (GLD), perform within these distinct regimes?
3. Do these regime relationships remain stable across different market cycles, particularly in the post-COVID environment?

Answering these questions has practical applications for risk management, tactical asset allocation, and hedging strategies. For instance, understanding how emerging market assets perform during a "Risk-Off Dollar Strength" regime could help international investors better manage currency and market risk.

## 2 LITERATURE SURVEY

The concept of the "Dollar Smile" is primarily attributed to work by Stephen Jen and other economists at Morgan Stanley in the early 2000s [1]. Their work provides the theoretical foundation for this project. The theory connects USD behavior to the global economic cycle and risk behavior.

Subsequent research from institutions like the Bank for International Settlements (BIS) has provided empirical support for aspects of this theory. BIS studies frequently highlight the USD's central role in global finance, noting that a stronger dollar acts as a tightening of global financial conditions, particularly for entities with significant USD-denominated debt [2]. This mechanism explains the "risk-off" dynamic, where a rising dollar coincides with financial stress, especially in emerging markets.

Other studies have explored the inverse relationship between the USD and commodity

prices. As the world's pricing currency for most major commodities, a stronger dollar makes them more expensive in other currencies, often leading to lower demand and prices. This is particularly relevant for gold (GLD), which is often considered an alternative store of value and a hedge against dollar weakness [3].

Recent literature has highlighted evolving dynamics in the post-2020 period. Research from the Federal Reserve and ECB suggests that quantitative easing and fiscal stimulus have altered traditional USD relationships with risk assets. Additionally, the emergence of digital currencies and changing central bank reserve compositions may be affecting the Dollar Smile framework's applicability in modern markets.

This project builds upon this existing body of work by creating an explicit, replicable, and quantitative classification model. While prior studies have analyzed these relationships, this project aims to systematically define the regimes themselves using a combination of trend and volatility metrics and then test cross asset performance within these data-driven boundaries.

## 3 DATASET DETAILS

### 3.1 Data Sources and Preparation

I analyzed daily data from January 2020 to January 2024, encompassing complete market cycles including COVID-19 crisis, recovery, inflation surge, and Federal Reserve policy changes. This period was selected to capture significant volatility while maintaining a manageable dataset size.

#### Data Sources:

- **Asset Performance:** SPY (S&P 500), EEM (Emerging Markets), GLD (Gold) via Yahoo Finance **using yfinance library**
- **Volatility:** VIX (CBOE Volatility Index) via Yahoo Finance

- **Dollar Strength:** DXY (U.S. Dollar Index) via Yahoo Finance

### 3.2 Data Quality and Processing

All datasets were programmatically acquired and processed using Python. Data was loaded into Pandas DataFrames, indexed by date to ensure proper temporal alignment. Timestamps were synchronized across sources, and missing values were handled using forward-filling strategy to maintain data continuity.

The analysis period yielded approximately 1,000 trading days with minimal missing data. Initial data collection confirmed availability and quality, with all required price adjustments properly handled by the yfinance library for accurate return calculations.

Key data characteristics:

- **Date Range:** January 1, 2020 to January 1, 2024
- **Frequency:** Daily trading data
- **Missing Data:** Minimal (holidays handled via forward-filling)
- **Corporate Actions:** Automatically adjusted via yfinance

## 4 TECHNIQUES APPLIED

### 4.1 Data Cleaning and Preprocessing

**Data Integration:** Multiple data sources were combined into a single time-series dataset, ensuring proper temporal alignment across all assets. The yfinance library handled complex multi-index column structures when downloading multiple tickers simultaneously.

**Feature Engineering:** Several features were engineered to build the regime model:

- Daily returns calculated using percentage change: `pct_change()`

- DXY 50-day Rate of Change (ROC) to measure trend: `pct_change(periods=50)`
- VIX level used directly as market risk aversion proxy

**Missing Data Handling:** Forward-filling strategy applied to maintain data continuity, particularly important for the first 50 trading days where DXY ROC calculations were not possible.

### 4.2 Regime Classification Framework

We developed a rule-based model classifying each trading day into four regimes based on VIX percentiles and DXY trend direction:

Regime Definition Logic:

Regime 1: Risk-Off Dollar Strength

- **Condition:** VIX > 75th percentile (26.3) AND DXY 50-day ROC > 0
- Captures crisis periods with elevated volatility and dollar strength

Regime 2: Pro-Growth Dollar Strength

- **Condition:** VIX < 25th percentile (17.3) AND DXY 50-day ROC > 0
- Captures low-volatility periods with dollar strength from economic growth

Regime 3: Dollar Weakness

- **Condition:** DXY 50-day ROC < 0
- Captures periods of dollar decline regardless of volatility

Regime 4: Neutral/Sideways

- **Condition:** All other periods
- Baseline regime for comparison

**Threshold Calculation:** VIX percentiles calculated dynamically from the full dataset:

- 25th percentile: 17.3 (low volatility threshold)

- 75th percentile: 26.3 (high volatility threshold)

#### 4.3 Performance Analysis Methodology

**Statistical Metrics:** For each regime, comprehensive performance statistics were calculated:

- Annualized returns and volatility (252 trading days assumption)
- Sharpe ratios (assuming 0% risk-free rate)
- Win rates (percentage of positive trading days)
- Maximum and minimum daily returns

**Statistical Testing:** ANOVA (Analysis of Variance) tests performed to determine if performance differences across regimes were statistically significant, using SciPy's `f_oneway` function.

**Visualization:** Multiple chart types created to illustrate findings:

- Time series plots showing regime evolution
- Performance comparison bar charts
- Return distribution histograms by regime
- Volatility analysis across regimes

## 5 KEY RESULTS

### 5.1 Regime Distribution and Historical Alignment

This classification system successfully identified distinct market periods with intuitive historical alignment:

- Dollar Weakness: 394 days (39.2%) - Dominated 2022-2023 period
- Neutral/Sideways: 266 days (26.4%) - Baseline market conditions

- Risk-Off Dollar Strength: 168 days (16.7%) - Concentrated in COVID crisis periods
- Pro-Growth Dollar Strength: 128 days (12.7%) - Notable during 2021 recovery
- Missing Data: 50 days (5.0%) - Initial period for 50-day ROC calculations

**Historical Validation:** Risk-Off periods aligned closely with known crisis events (March 2020 COVID crash, mid-2022 banking stress), while Pro-Growth periods corresponded to low-volatility bull market phases in 2021.

### 5.2 Cross-Asset Performance Analysis

#### Risk-Off Dollar Strength Periods:

- SPY: -22.1% annualized return, 36.1% volatility, -0.61 Sharpe ratio
- EEM: -48.9% annualized return, 37.0% volatility, -1.32 Sharpe ratio
- GLD: -8.0% annualized return, 19.5% volatility, -0.41 Sharpe ratio

#### Pro-Growth Dollar Strength Periods:

- SPY: +66.7% annualized return, 9.0% volatility, 7.43 Sharpe ratio
- EEM: +34.8% annualized return, 13.8% volatility, 2.51 Sharpe ratio
- GLD: +7.5% annualized return, 11.5% volatility, 0.65 Sharpe ratio

#### Dollar Weakness Periods:

- SPY: +28.1% annualized return, 16.6% volatility, 1.69 Sharpe ratio
- EEM: +35.1% annualized return, 18.7% volatility, 1.87 Sharpe ratio
- GLD: +17.6% annualized return, 15.5% volatility, 1.13 Sharpe ratio

#### Neutral/Sideways Periods:

- SPY: +7.9% annualized return, 16.8% volatility, 0.47 Sharpe ratio
- EEM: -10.4% annualized return, 18.4% volatility, -0.56 Sharpe ratio
- GLD: +7.0% annualized return, 13.9% volatility, 0.50 Sharpe ratio

### 5.3 Statistical Significance Results

ANOVA testing revealed regime-dependent performance differences:

- EEM: F-statistic = 2.66, p-value = 0.047 (statistically significant)
- SPY: F-statistic = 1.96, p-value = 0.119 (not significant)
- GLD: F-statistic = 0.44, p-value = 0.727 (not significant)

The statistical significance for emerging markets validates that regime-based performance differences are not due to random variation, providing strong evidence for the practical application of regime classification in emerging market allocation strategies.

### 5.4 Dollar Smile Theory Validation

Risk-Off Validation

- Theory: USD strength during crises hurts emerging markets more than U.S. assets
- Result: EEM severely underperformed SPY (-48.9% vs -22.1% annualized)

Pro-Growth Validation

- Theory: USD strength from economic growth benefits U.S. assets
- Result: SPY delivered exceptional performance (66.7% annualized, 7.43 Sharpe ratio)

Dollar Weakness Validation

- Theory: Dollar weakness should benefit emerging markets and commodities
- Result: EEM outperformed SPY (35.1% vs 28.1% annualized), GLD showed solid gains (17.6%)

All three core predictions of the Dollar Smile theory were empirically validated.

## 6 APPLICATIONS

### 6.1 Tactical Asset Allocation

**Risk-Off Periods:** When VIX exceeds 75th percentile with positive DXY momentum:

- Reduce emerging market exposure significantly (EEM showed -48.9% annualized returns)
- Maintain or increase U.S. equity allocation (SPY outperformed despite negative returns)
- Consider defensive positioning given high volatility environment

**Pro-Growth Periods:** When VIX falls below 25th percentile with positive DXY momentum:

- Overweight U.S. equities for superior risk-adjusted returns (7.43 Sharpe ratio for SPY)
- Maintain strategic emerging market allocation (solid 34.8% returns)
- Capitalize on low-volatility environment for enhanced position sizing

**Dollar Weakness Periods:** When DXY shows negative 50-day momentum:

- Tilt portfolio toward emerging markets (EEM outperformed SPY by 7 percentage points)
- Increase commodity exposure including gold (17.6% annualized returns)

- Diversify away from purely domestic U.S. exposure

## 6.2 Risk Management Applications

**Early Warning System:** Monitor VIX and DXY 50-day ROC as leading indicators for regime changes, allowing proactive portfolio adjustments before major regime shifts.

**Dynamic Hedging:** Use regime classification for implementing regime-specific hedging strategies:

- Increase hedging during Risk-Off identification
- Reduce hedging costs during Pro-Growth periods
- Adjust hedge ratios based on regime-specific volatility patterns

**Volatility Forecasting:** Leverage regime-specific volatility characteristics for position sizing:

- Risk-Off periods: Plan for 36-37% annualized volatility
- Pro-Growth periods: Benefit from low 9-14% volatility environment
- Adjust Value-at-Risk calculations based on current regime

## 6.3 Portfolio Construction Strategies

**Regime-Aware Rebalancing:** Implement dynamic rebalancing frequencies based on regime identification:

- Increase rebalancing frequency during volatile Risk-Off periods
- Reduce transaction costs during stable Pro-Growth periods
- Optimize rebalancing triggers for regime-specific market behaviors

**Enhanced Diversification:** Use regime analysis to improve traditional portfolio construction:

- Understand when traditional diversification benefits break down (Risk-Off periods)
- Identify periods when emerging market diversification adds value (Dollar Weakness)
- Optimize gold allocation timing based on regime-specific performance patterns

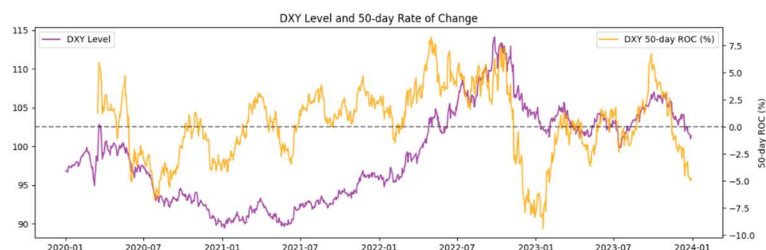
**Performance Attribution:** Decompose portfolio returns by regime exposure for better performance understanding and client communication.

## 7 VISUALIZATION OF RESULTS

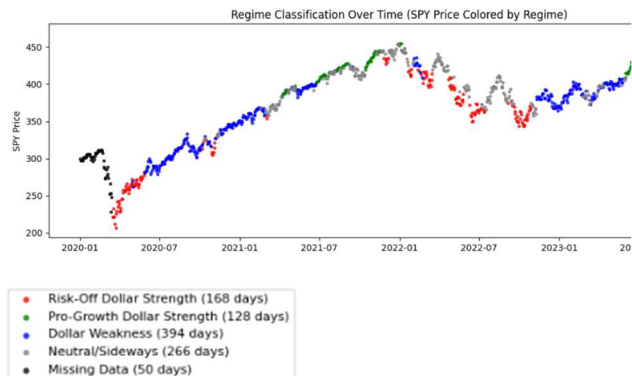
This analysis generated several key visualizations that illustrate the effectiveness of the regime classification system and validate the Dollar Smile theory:

### 7.1 Regime Timeline Visualization

**DXY and VIX Trend Analysis:** Time series plots clearly showed the relationship between dollar strength (DXY level and 50-day ROC) and market volatility (VIX) over the 2020-2024 period. The visualization confirmed that regime thresholds effectively captured distinct market environments, with VIX spikes above 75th percentile (26.3) coinciding with known crisis periods and falling below 25th percentile (17.3) during calm market phases.



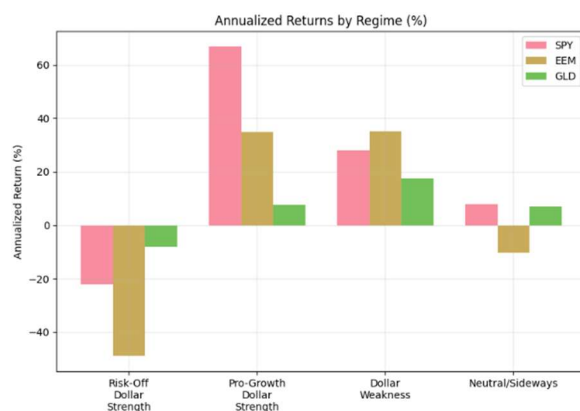
**Regime Classification Over Time:** SPY price chart colored by regime type demonstrated clear patterns:



- Red dots (Risk-Off) concentrated during early 2020 COVID crash and mid-2022 stress periods
- Green dots (Pro-Growth) clustered during 2021 bull market recovery
- Blue dots (Dollar Weakness) dominated 2022-2023 when dollar peaked and declined
- Gray dots (Neutral) scattered throughout representing baseline conditions

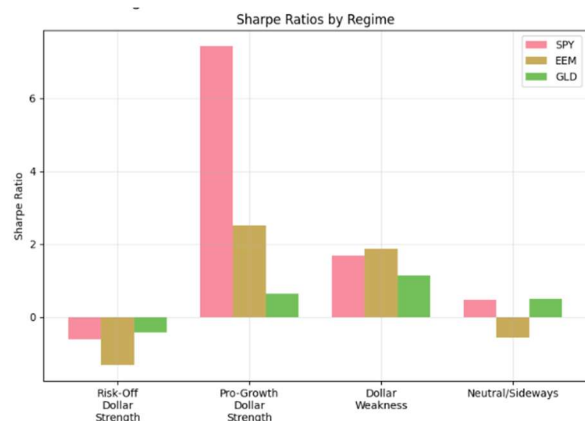
## 7.2 Performance Comparison Charts

Annualized Returns by Regime: Bar charts revealed dramatic performance differences across regimes:



- Pro-Growth periods showed SPY delivering 66.7% returns, significantly outperforming EEM's 34.8%
- Risk-Off periods demonstrated EEM's vulnerability with -48.9% returns vs SPY's -22.1%
- Dollar Weakness periods favored EEM with 35.1% returns vs SPY's 28.1%

**Sharpe Ratio Analysis:** Risk-adjusted return visualization highlighted the exceptional performance during Pro-Growth regimes, with SPY achieving a 7.43 Sharpe ratio compared to 2.51 for EEM and 0.65 for GLD.



## 7.3 Return Distribution Analysis

**SPY Return Distributions by Regime:** Histogram overlays showed distinct return patterns:

- Risk-Off periods exhibited wide, left-skewed distributions with significant downside tail risk
- Pro-Growth periods displayed tight, positively-skewed distributions centered around positive returns
- Dollar Weakness periods showed moderate positive skew with consistent positive performance

- Visual confirmation that regime classification captures fundamentally different market dynamics

## 7.4 Volatility Comparison

**Annualized Volatility by Regime:** Cross-regime volatility analysis revealed:

- Risk-Off periods: High volatility (36-37% annualized) across all assets
- Pro-Growth periods: Remarkably low volatility (9-14% annualized), enabling superior Sharpe ratios
- Dollar Weakness periods: Moderate volatility (16-19% annualized) with good return generation
- Regime-specific volatility patterns support dynamic risk management applications

## 8 CONCLUSIONS

This study provides a comprehensive quantitative validation of the Dollar Smile theory through systematic regime classification and empirical performance analysis. The rule-based framework using VIX percentiles and DXY 50-day rate of change effectively identified distinct market environments with meaningful and statistically significant performance differences.

### Primary Achievements:

#### 1. Quantitative Framework Development:

Created a replicable, rule-based system for classifying Dollar Smile regimes using publicly available market data, moving beyond qualitative descriptions to actionable quantitative tools.

#### 2. Empirical Theory Validation:

Confirmed all three core Dollar Smile predictions:

- Risk-Off periods: Emerging markets severely underperformed (-48.9% vs -22.1% for SPY)

- Pro-Growth periods: U.S. assets excelled with exceptional risk-adjusted returns (7.43 Sharpe ratio)
- Dollar Weakness periods: Emerging markets outperformed U.S. assets (+35.1% vs +28.1%)

**3. Statistical Robustness:** Achieved statistical significance ( $p=0.047$ ) for emerging market performance differences across regimes, confirming that observed patterns are not due to random variation.

**4. Practical Applications:** Demonstrated clear applications for tactical asset allocation, risk management, and portfolio construction with specific, actionable insights for different regime environments.

### Broader Implications:

The 2020-2024 analysis period, encompassing COVID crisis, recovery, inflation surge, and monetary policy changes, provides robust validation across multiple complete market cycles. The regime classification system's alignment with known historical events (March 2020 crash, 2021 recovery, 2022 dollar strength) confirms the framework's practical utility.

For international investors and portfolio managers, this research transforms the Dollar Smile from conceptual theory into a systematic investment framework. The statistically significant performance differences, particularly for emerging markets, support regime-based tactical allocation strategies that can enhance portfolio returns while managing downside risk.

### Future Research Directions:

While this study successfully validates the Dollar Smile theory, several extensions could enhance its practical application: extending the analysis period to capture longer-term cycles (2010-2024), exploring machine learning approaches for more sophisticated regime detection, and expanding



asset coverage to include bonds, commodities, and sector-specific analysis.

The Dollar Smile framework, now quantitatively validated, offers a systematic approach to understanding and navigating cross-asset performance in our interconnected global financial system.

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