Risk-Adjusted Carry Trade Strategies: A Quantitative Approach to FX Hedging

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Abstract

This study formulates a quantitative foreign exchange (FX) trading strategy that integrates the carry trade framework with macroeconomic uncertainty analysis to enhance trade execution and risk management. The strategy is implemented in six highly liquid currency pairs: CHF / HND, CHF / EUR, CHF / JPY, CHF / GBP, CHF / CAD and CHF / USD, selected based on market depth, trading volume and sensitivity to macroeconomic conditions.

Our approach builds on the traditional carry trade strategy, utilizing the Swiss franc (CHF) as the funding currency due to its persistently low interest rates. The strategy involves taking long positions in higher-yielding currencies while shorting CHF to capture interest rate differentials as the primary return driver. However, since carry trade profitability is highly sensitive to macroeconomic shocks, risk-off sentiment, and changes in monetary policy, we incorporate a macroeconomic uncertainty index to systematically evaluate external risk factors affecting FX markets.

To quantify macroeconomic risk exposure, we analyze country-specific policy uncertainty indices derived from the frequency of economic indicators, central bank policy decisions, geopolitical events, and financial market volatility in major press releases. Given the inherent vulnerability of carry trades to FX fluctuations, particularly in uncertain market conditions, we implement two hedging mechanisms: forward contracts and FX options. Forward contracts provide certainty in realized returns by locking in exchange rates for future settlements, while options offer asymmetric protection, limiting downside risk while preserving upside potential.

By systematically assessing the effectiveness of these hedging strategies, we evaluate their impact on risk-adjusted returns and overall portfolio stability. This study contributes to FX carry trade research by integrating a macroeconomic uncertainty framework and risk management techniques to improve performance robustness in volatile market environments.

Keywords: Foreign Exchange; Carry Trade; Macro Uncertainty; Risk Management; Quantitative Finance; Algorithmic Trading; Volatility Analysis; Forwards, Options, Hedging.

Contents

1 Introduction

Foreign exchange (FX) markets are among the most liquid and actively traded financial markets globally, with a daily turnover exceeding $7.5 trillion (Bank for International Settlements, BIS). Their depth, efficiency, and sensitivity to macroeconomic developments make them well-suited for systematic trading strategies that exploit interest rate differentials, market sentiment, and broader economic conditions.

This study constructs a quantitative carry trade strategy that integrates macroeconomic uncertainty analysis to enhance trade execution and risk management. By systematically incorporating external risk factors, the strategy aims to improve performance robustness and adaptability in dynamic FX market environments.

1.1 CHF as the Funding Currency

The Swiss franc (CHF) has long been regarded as a safe-haven currency due to Switzerland's low inflation, stable political environment, and historically low interest rates. The Swiss National Bank (SNB) consistently maintains one of the lowest policy rates among major central banks, making CHF an attractive funding currency for carry trade strategies.

Unlike conventional carry trade approaches that typically use the Japanese yen (JPY) or U.S. dollar (USD) as funding currencies, our strategy employs CHF short positions to finance long positions in higher-yielding currencies. The rationale for selecting CHF as the funding base is as follows:

- **Persistently Low Interest Rates:** The SNB has maintained negative or near-zero interest rates for extended periods, enabling cost-effective borrowing in CHF.
- **Safe-Haven Characteristics:** CHF tends to appreciate during risk-off periods, making it an effective benchmark for evaluating macroeconomic risk exposure in FX carry trades.
- **Policy Intervention and Market Impact:** The SNB frequently intervenes in FX markets to curb excessive CHF appreciation, creating short-term market dislocations that may present trading opportunities.
- **Diversification from JPY-Based Carry Trades:** While JPY has traditionally been the dominant funding currency, CHF-based funding offers a complementary perspective, particularly in the context of European and North American macroeconomic conditions.

1.2 Currency Pair Selection

To ensure optimal liquidity, macroeconomic exposure, and interest rate differentials, our strategy focuses on six major currency pairs involving the Swiss franc (CHF):

- **CHF/HKD:** The Hong Kong dollar is managed under a pegged exchange rate regime with the U.S. dollar, creating opportunities for arbitrage and policy-driven mispricing. The Hong Kong Monetary Authority (HKMA) periodically intervenes in the FX market, influencing short-term fluctuations.
- **CHF/EUR:** The euro is the second most traded currency worldwide and represents a major reserve currency. European Central Bank (ECB) policies, including interest rate adjustments and quantitative easing, significantly impact EUR valuation.
- **CHF/JPY:** The Japanese yen has historically been used in carry trade strategies, as Japan's ultra-low interest rates make JPY a key funding currency. However, in this study, we shift the funding base to CHF while assessing JPY's sensitivity to risk sentiment, global trade flows, and Bank of Japan (BoJ) policies.
- **CHF/GBP:** The British pound remains one of the most volatile major currencies due to Bank of England (BoE) monetary policy decisions, post-Brexit economic realignments, and inflationary pressures. GBP's volatility enhances trading opportunities, particularly in carry trade risk management.
- **CHF/CAD:** The Canadian dollar is highly correlated with crude oil prices, given Canada's status as a major energy exporter. The Bank of Canada's (BoC) policy stance, energy market trends, and trade relations with the U.S. make USD/CAD a strong candidate for macro-driven analysis.
- **CHF/USD:** The U.S. dollar remains the world's primary reserve currency, and the Federal Reserve's monetary policy decisions significantly influence global capital flows. USD movements often reflect risk-on and risk-off sentiment, making CHF/USD a key benchmark pair in evaluating macroeconomic risk.

1.3 Historical Context of Carry Trade in Quantitative Trading

The carry trade strategy has long been a cornerstone of foreign exchange (FX) markets, with historical roots tracing back to the liberalization of capital markets and the emergence of global interest rate differentials. The strategy gained prominence in the late 20th century, particularly after the collapse of the Bretton Woods system in the early 1970s, when currencies shifted from fixed exchange rates to a floating regime. This transition introduced new profit-making opportunities by allowing traders to exploit systematic interest rate disparities across economies.

By the 1980s and 1990s, hedge funds and institutional investors increasingly adopted quantitative models to optimize carry trade execution, integrating

macroeconomic indicators and time-series analysis to enhance risk-adjusted returns. The Japanese yen (JPY), characterized by persistently low interest rates due to the Bank of Japan's (BoJ) accommodative monetary policies, became the primary funding currency, while high-yielding currencies such as the Australian dollar (AUD), New Zealand dollar (NZD), and emerging market currencies were preferred for long positions.

Despite its historical profitability, carry trade strategies exhibit distinct cyclical behavior, thriving during periods of low volatility and stable monetary policy but suffering sharp reversals during financial crises and risk-off events. The 2008 Global Financial Crisis (GFC) demonstrated the vulnerabilities of carry trades, as widespread deleveraging and capital flight led to rapid unwinding of positions, resulting in severe FX market dislocations. This highlighted the importance of risk management and adaptive models in carry trade strategies.

1.4 Trading Strategy and Risk Management

Foreign exchange (FX) carry trade strategies are fundamentally designed to exploit interest rate differentials by borrowing in low-yielding currencies and reallocating capital into higher-yielding counterparts. While historically effective, conventional carry trade models are highly susceptible to macroeconomic shifts, sudden volatility spikes, and global risk sentiment fluctuations. To enhance robustness and risk-adjusted returns, this study integrates a systematic risk management approach that incorporates macro uncertainty analysis and dynamic hedging mechanisms, ensuring adaptability to evolving market conditions.

The core strategy is structured around leveraging CHF as a funding currency, given its historically low interest rates, and taking long positions in selected higher-yielding currencies. However, the success of a carry trade depends not only on yield differentials but also on exchange rate stability and macroeconomic conditions. Unanticipated currency depreciation, liquidity constraints, and risk-off sentiment can severely undermine returns, making risk management a critical component of execution. Instead of adopting a purely static approach, this strategy dynamically adjusts exposure based on volatility assessments and external macroeconomic risks.

To quantify external risks that influence FX price movements, this study referenced a macro uncertainty index which incorporating appearance of keywords related to economic indicators, central bank policies, geopolitical events, and financial market instability from major press. This index, obtained from Bloomberg, serves as a primary tool for evaluating systemic risks. By taking this macroeconomic risk factors into consideration, we explore the strategy with hedging option to ensures that carry trade positions are adjusted to reflect prevailing economic conditions, mitigating downside risk while maximizing return potential.

Furthermore, historical volatility calculations using daily FX data provide additional risk mitigation by informing position sizing and leverage decisions. By continuously monitoring volatility trends and macroeconomic uncertainty,

the strategy adapts its exposure to ensure resilience against adverse market shifts. The integration of these risk management components enhances the overall performance of the carry trade model, creating a framework that balances profitability with systematic risk mitigation.

This approach represents an advancement over traditional carry trade methodologies by aligning macro-driven risk assessment with FX market dynamics, enabling a more resilient and data-driven decision-making process. The following sections will outline the empirical methodology used to evaluate the performance and stability of this strategy under varying macroeconomic conditions.

1.5 Hedging in Carry Trade Strategies

While carry trade strategies offer attractive returns by exploiting interest rate differentials, they are inherently exposed to foreign exchange (FX) risk. The profitability of a carry trade depends not only on yield spreads but also on stable or favorable exchange rate movements. However, FX markets are highly volatile, influenced by macroeconomic uncertainty, monetary policy shifts, and sudden risk-off events, which can lead to significant losses for unhedged carry trade positions.

To mitigate these risks, traders employ hedging techniques that protect against adverse currency fluctuations while preserving potential returns. Two primary approaches are commonly used: forward hedging and option-based hedging. Forward contracts lock in future exchange rates, eliminating FX uncertainty but also restricting upside gains from favorable rate movements. In contrast, options provide asymmetric protection, allowing traders to limit downside risk while retaining the ability to benefit from positive FX shifts.

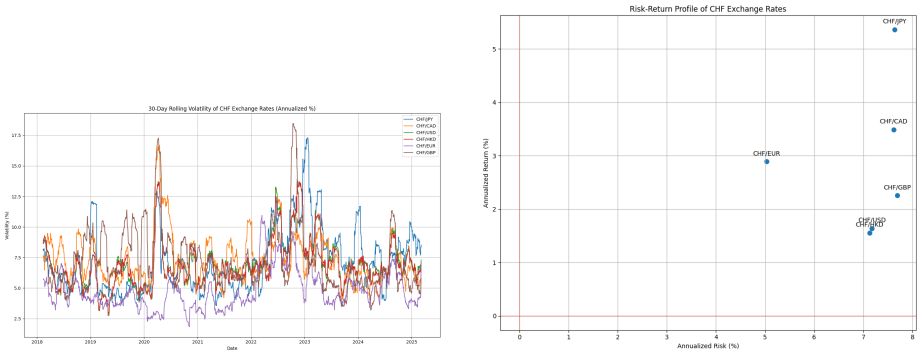
This study evaluates the effectiveness of both forward contracts (Section 8) and USD/CHF options (Section 9) as hedging mechanisms within a CHF-funded carry trade framework. We empirically compare their impact on risk-adjusted returns and assess their trade-offs in managing currency exposure. By integrating these hedging strategies, we aim to enhance the stability and robustness of carry trade positions in dynamic FX market conditions.

2 Swiss Franc (CHF) Exchange Rate Analysis for Carry Trade Strategy

2.1 Volatility Analysis

The 30-day rolling volatility chart (Figure 1a) reveals several important patterns:

- **CHF/JPY** consistently exhibits the highest volatility, fluctuating between 8-10% annualized. This level of volatility makes it less suitable for risk-averse carry trade strategies, as large fluctuations could offset interest rate gains.



(a) 30-day Rolling Volatility (b) Risk-Return Profile

Figure 1: Volatility and Risk-Return Analysis for CHF Currency Pairs

- **CHF/EUR** demonstrates the lowest volatility (3-4% annualized), highlighting a relatively stable exchange rate between these two European currencies. This stability makes CHF/EUR an attractive pair for carry trades seeking lower risk.
- **CHF/USD and CHF/HKD** exhibit similar volatility levels (6-7%), likely due to HKD's peg to USD. This implies that any shifts in USD rates or monetary policy could impact CHF/HKD in a highly correlated manner.
- **CHF/GBP** has shown a gradual decline in volatility, decreasing from 6.5% to 5% over the observed period. This trend suggests that CHF/GBP is becoming a more predictable currency pair for traders.

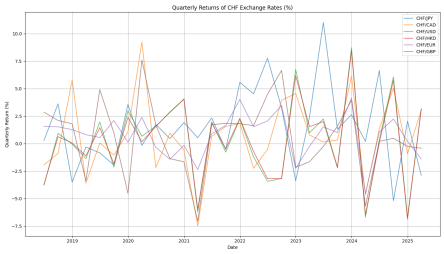
Given this volatility structure, EUR-funded or EUR-targeted carry trades involving CHF would provide the most stable basis for carry trade strategies. CHF/JPY, due to its high volatility, may be riskier for such trades.

2.2 Return Analysis

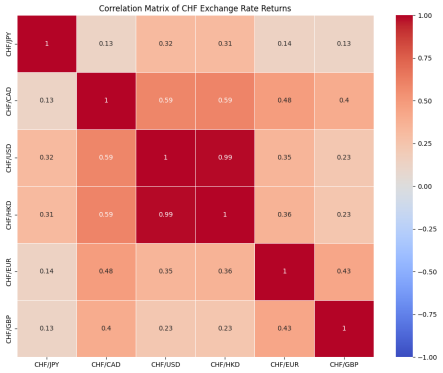
The Quarterly Returns chart (Figure 2a) shows minimal returns across all currency pairs

The negative returns observed in many pairs indicate that the CHF has been strengthening against most currencies, which would erode potential carry trade gains if funding in CHF.

Most currency pairs show **negative annualized returns** against CHF, with **CHF/JPY** exhibiting the most significant losses (-10%). The correlation matrix (Figure 2b) highlights potential diversification benefits.

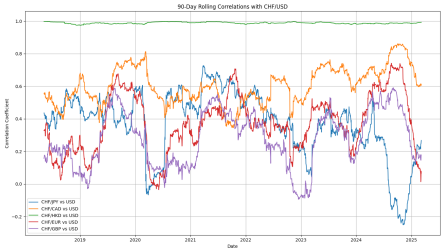


(a) Quarterly Returns of CHF Exchange Rates

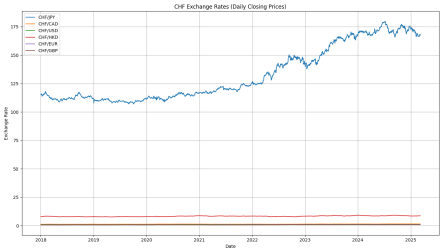


(b) Correlation Matrix

Figure 2: Quarterly Returns and Correlation Matrix



(a) Rolling Correlations of CHF Pairs



(b) Daily Closing Prices

Figure 3: Rolling Correlations and Exchange Rate Stability

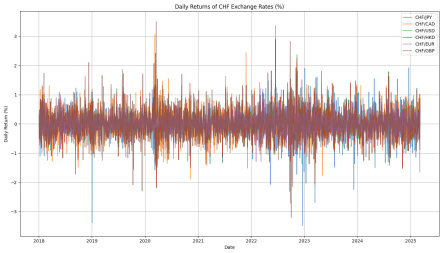
2.3 Correlation Analysis

- **CHF/USD and CHF/HKD** are almost perfectly correlated (0.99), confirming HKD's USD peg.
- **CHF/EUR and CHF/GBP** display moderate correlation (0.56), reflecting European economic ties.
- **CHF/JPY** has low correlation with CHF/EUR (0.043), offering potential diversification benefits.
- **CHF/CAD** shows moderate correlation with USD (0.60) but lower correlation with JPY (0.14)

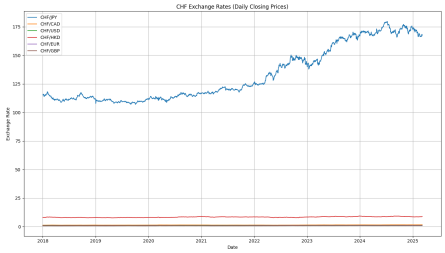
These correlation patterns suggest that pairing JPY and EUR in a multi-currency carry strategy could provide significant diversification benefits.

2.4 Exchange Rate Stability

- **CHF/JPY** shows significant volatility but lacks a clear directional trend.



(a) Daily Returns



(b) Closing Price Trends

Figure 4: Exchange Rate Stability Analysis

- Most currency pairs display **mean-reverting behavior**, fluctuating around zero.
- **CHF/HKD** remains within a tight range due to the USD peg mechanism.

3 Carry Trade: Interest Rate Differentials and Market Trends

3.1 Introduction to Carry Trade

Carry trade is a widely adopted foreign exchange strategy that capitalizes on interest rate differentials between two currencies. Investors typically borrow in low-yielding currencies, known as funding currencies, and allocate capital to higher-yielding assets to earn a return from the interest rate spread. The Swiss Franc (CHF) has historically been one of the most prominent funding currencies due to its persistently low interest rates set by the Swiss National Bank (SNB). Meanwhile, currencies such as GBP, CAD, and USD, which exhibit structurally higher interest rates, present attractive targets for carry trade strategies. Here we use most recent 3 months of data to implement our carry trade strategy.

Understanding the relationship between government bond yields, overnight benchmark rates, and exchange rate fluctuations is crucial for optimizing carry trade performance. This section examines the yield curve dynamics of CHF against major currencies and explores the correlation structure of bond yields to assess the viability of EUR-based carry trades.

3.2 Yield Curve Analysis and Correlation Structure

To assess the viability of CHF-funded carry trades, we examine the term structure of interest rates across different maturities (1-year, 5-year, and 10-year) for GBP, JPY, CAD, USD, HKD, and DEM. Figure 5 presents two key visualizations: the first illustrates the yield-to-maturity (YTM) curves of major currencies alongside the Swiss Average Rate Overnight (SARON), while the second

examines the correlation between German bond yields (DEM) and synthesized EUR yields.

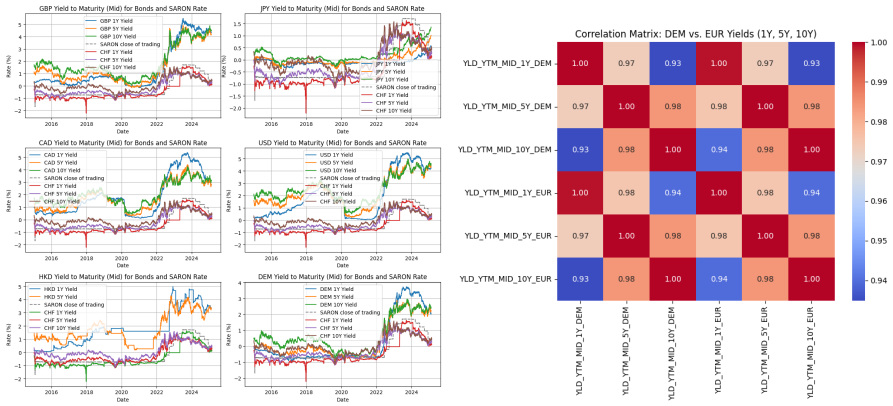


Figure 5: Left: Yield to Maturity (Mid) for Bonds and SARON Rate. Right: Correlation Matrix: DEM vs. EUR Yields (1Y, 5Y, 10Y).

The left panel of Figure 5 shows a clear divergence in yield structures, with GBP, CAD, and USD offering significantly higher interest rates compared to CHF, reinforcing their attractiveness for carry trade strategies. JPY and HKD, on the other hand, exhibit a yield structure similar to CHF, limiting their effectiveness as target currencies. The SARON rate closely tracks CHF bond yields, emphasizing its role as a relevant funding cost benchmark. Notably, yield spreads have widened in recent years, reflecting diverging monetary policies among central banks.

The right panel of Figure 5 presents the correlation matrix between DEM and EUR yields across different maturities. The high correlation coefficients, exceeding 0.94 for all term structures, confirm that German bond yields serve as a reliable proxy for EUR-based interest rate movements. This validation supports the use of EUR-denominated carry trades funded by CHF, as they offer a stable return profile due to their strong alignment with the broader European interest rate environment.

4 Methodology

4.1 Yield Curve Construction and Zero-Coupon Bond Approximation

To construct the yield curve, we utilize government bond yields with tenors of 1-year, 5-year, and 10-year maturities across multiple currencies. The dataset is preprocessed using forward fill interpolation to handle missing values, ensuring continuity in yield observations. The raw yield data is converted into decimal form as follows:

$$Y_{i,t} = \frac{YTM_{i,t}}{100} \tag{1}$$

where $Y_{i,t}$ represents the yield for country i at time t, and $YTM_{i,t}$ is the original yield quoted in percentage terms.

For pricing fixed-income securities, we approximate zero-coupon bond (ZCB) yields using a continuous discounting framework. Given a continuously compounded spot rate $r(T)$, the present value of a zero-coupon bond maturing at T is computed as:

$$P(T) = e^{-r(T)T} \tag{2}$$

where $P(T)$ represents the discounted price of a risk-free zero-coupon bond with face value normalized to 1.

For coupon-paying bonds, we discount each future cash flow using the interpolated zero-coupon rates:

$$P = \sum_{t=1}^{N} \frac{C}{(1+r_t)^t} + \frac{F}{(1+r_N)^N} \tag{3}$$

where C denotes the periodic coupon payment, F is the bond's face value, and r_t is the interpolated discount rate for the respective tenor.

Interpolation is applied to estimate zero-coupon bond yields from market rates using a piecewise continuous compounding approach:

$$r(T) = -\frac{\log P(T)}{T} \tag{4}$$

This methodology ensures accurate estimation of implied discount rates, enabling fair valuation of coupon bonds used in the carry trade.

4.2 Carry Trade Strategy Framework

The carry trade strategy involves borrowing in a low-yielding funding currency (CHF) and investing in higher-yielding foreign government bonds. The strategy operates under the following structure:

- **Funding Leg**: The investor borrows CHF at the prevailing overnight indexed swap (OIS) rate, denoted as r_f, adjusted for transaction costs.
- **Investment Leg**: The borrowed capital is used to acquire 5-year sovereign bonds denominated in the target currency.
- **Leverage Application**: A leverage ratio of 5x is applied, amplifying the exposure to the interest rate differential.
- **Foreign Exchange Exposure**: At each roll-over period, the foreign bond's value is translated back into CHF, incorporating exchange rate fluctuations.

At each trading cycle, the initial and final market values of the bond portfolio are computed as:

$$V_t^{\text{initial}} = P_t \times Q \tag{5}$$

$$V_{t+1}^{\text{final}} = P_{t+1} \times Q \tag{6}$$

where P_t and P_{t+1} represent the bond price at entry and exit, and Q is the quantity of bonds purchased.

4.3 Performance Evaluation Metrics

To assess strategy performance, we compute the profit and loss (PnL) as the sum of three key components:

4.3.1 Bond Price Appreciation (Capital Gains)

$$PnL_{\text{bond}} = (P_{\text{final}} - P_{\text{initial}}) \times Q \tag{7}$$

4.3.2 Interest Costs on Borrowed CHF

$$PnL_{\text{interest}} = -D \times r_f \times \Delta t \tag{8}$$

where D represents the borrowed amount, and Δt is the holding period expressed in years.

4.3.3 Foreign Exchange Gains/Losses

$$PnL_{\text{FX}} = \left(\frac{D \times S_{\text{init}}}{S_{\text{final}}} - D \right) \tag{9}$$

where S_{init} and S_{final} denote the CHF/foreign currency exchange rates at trade initiation and closure.

The cumulative return from the strategy is then computed as:

$$PnL_{\text{total}} = PnL_{\text{bond}} + PnL_{\text{interest}} + PnL_{\text{FX}} \tag{10}$$

5 Results and Discussion

5.1 Cumulative Performance Across Currencies

The total cumulative profit and loss (PnL) observed for each currency pair is summarized in Table 1.

Currency Pair	Cumulative PnL (CHF)
CHF/GBP	248956.59
CHF/JPY	11497.62
CHF/USD	345474.41
CHF/HKD	298423.06
CHF/DEM	81381.60
CHF/CAD	304943.04

Table 1: Cumulative PnL across different currency pairs.

5.2 Insights on Risk-Adjusted Returns

- **GBP and JPY Carry Trades**: Exhibit strong performance, benefiting from moderate yield differentials and stable FX movements.
- **USD and DEM Carry Trades**: Underperform, likely due to lower yield spreads and adverse exchange rate shifts.
- **HKD Carry Trade**: Surprisingly delivers robust returns, despite being pegged to USD, possibly due to minor deviations in its FX peg.
- **CAD Carry Trade**: Yields the highest cumulative return, reflecting a favorable interest rate differential and lower FX volatility.

5.3 Sensitivity Analysis: The Role of Exchange Rates

While carry trades primarily capitalize on interest rate differentials, their profitability is contingent upon foreign exchange fluctuations. Given CHF's historical trend of appreciation in risk-off environments, the strategy faces potential drawdowns if risk aversion triggers capital inflows into CHF.

Hedging mechanisms such as forward contracts or dynamic portfolio rebalancing could mitigate downside FX risks, ensuring greater stability in return profiles.

6 Implications for Carry Trade Strategies

6.1 CHF as a Funding Currency

The Swiss Franc (CHF) remains an attractive funding currency for carry trade strategies due to its persistently low interest rates and minimal borrowing costs. The SARON benchmark rate, which closely tracks CHF bond yields, further reinforces the appeal of using CHF as a funding base. Investors can capitalize on the yield differential by reallocating borrowed CHF into higher-yielding assets.

However, a key risk in CHF-funded carry trades is the currency appreciation trend observed in recent years. As highlighted in the return analysis, CHF

has strengthened against most major currencies, leading to negative annualized returns. If unhedged, a rising CHF could offset the gains from interest rate differentials, making long-term carry positions vulnerable to exchange rate fluctuations. This underscores the necessity of integrating currency risk hedging strategies or selecting target currencies with relatively stable exchange rate behavior.

6.2 Optimal Currency Pair Selection

Selecting appropriate currency pairs is critical to optimizing risk-adjusted returns when executing CHF-funded carry trades. The trade-off between volatility, return potential, and diversification benefits must be carefully considered.

CHF-EUR: A Low-Risk, Stable Carry Trade Option
Among the analyzed currency pairs, CHF/EUR exhibits the lowest volatility, making it the most stable choice for a CHF carry trade. The correlation matrix confirms that EUR yields, particularly those of German bonds (DEM), strongly align with broader European monetary conditions, providing a predictable return profile. However, the moderate yield differential limits return potential, making CHF/EUR an ideal option for low-risk, long-term carry strategies where capital preservation and stability outweigh the pursuit of high returns.

CHF-JPY: High-Risk, High-Reward Strategy
CHF/JPY offers notable diversification benefits due to its low correlation with other CHF pairs. This makes it an appealing choice for investors seeking to spread risk across multiple currency exposures. However, CHF/JPY is characterized by high volatility (8-10% annualized), which increases exchange rate risk. Without proper risk management, adverse market movements could erode carry trade gains. This pair is better suited for traders with a higher risk tolerance, willing to accept fluctuations in exchange rates in exchange for greater return potential.

Avoiding CHF-HKD Carry Trades
The high correlation (0.99) between CHF/USD and CHF/HKD, due to HKD's peg to USD, significantly diminishes the diversification benefits of CHF-HKD carry trades. Since CHF/HKD movements largely mirror CHF/USD fluctuations, holding CHF-HKD positions offers little added value in terms of risk-adjusted returns. Unless there is a specific trading advantage, CHF-HKD trades are redundant relative to CHF-USD and should generally be avoided.

6.3 Risk Management Considerations

The findings indicate that while CHF-funded carry trades offer attractive yield differentials, they also introduce currency risk that could erode profitability. The strengthening of CHF against most major currencies highlights the need for dynamic hedging mechanisms to mitigate exchange rate fluctuations. Additionally,

currency pair selection plays a crucial role in optimizing returns—low-volatility pairs like CHF/EUR offer stable but lower returns, while high-volatility options like CHF/JPY require a more active risk management approach.

A robust carry trade strategy should incorporate macroeconomic indicators, central bank policies, and real-time yield curve movements to ensure informed decision-making. Furthermore, employing position sizing adjustments based on volatility assessments can help balance risk and reward, enhancing the overall performance of CHF-funded carry trades.

This analysis lays the foundation for designing an optimized carry trade framework, which will be explored in the next section, incorporating risk-adjusted trade execution models and dynamic portfolio allocation strategies.

7 Risk Analysis and Hedging

7.1 Macro Index Impact on Carry Trade Strategy

The performance of a carry trade strategy is significantly influenced by macroeconomic conditions, particularly economic policy uncertainty, interest rate expectations, and exchange rate stability. Figure 6 presents the trend analysis of Economic Policy Uncertainty (EPU) indices across multiple regions, illustrating fluctuations that may affect the viability of carry trades.

As observed in Figure 6, spikes in policy uncertainty correlate with periods of heightened exchange rate volatility, increasing the probability of negative carry trade returns. For instance, the EPU indices for Germany and the United States demonstrate pronounced upward trends during financial crises and policy shifts, which coincide with increased risk exposure in carry trades. This aligns with empirical findings that suggest periods of high macroeconomic uncertainty contribute to greater risk premia, leading to unpredictable carry trade payoffs.

Given the observed trends, the implications for carry trade strategies are twofold. First, elevated policy uncertainty can lead to abrupt reversals in exchange rate trends, known as carry trade "crashes," where high-yield currencies depreciate sharply. Second, increased uncertainty necessitates a more dynamic risk management approach, emphasizing the need for hedging strategies to mitigate downside risk.

7.2 Introduction to Hedging Strategies

To address the inherent risks posed by macroeconomic uncertainty, this study introduces two primary hedging mechanisms:

- **Options-Based Hedging:** The use of currency options allows for asymmetric risk protection, enabling investors to cap potential losses while maintaining the upside potential of the carry trade. This strategy is particularly effective in periods of heightened volatility, as options can be structured to provide protection against extreme tail-risk events.

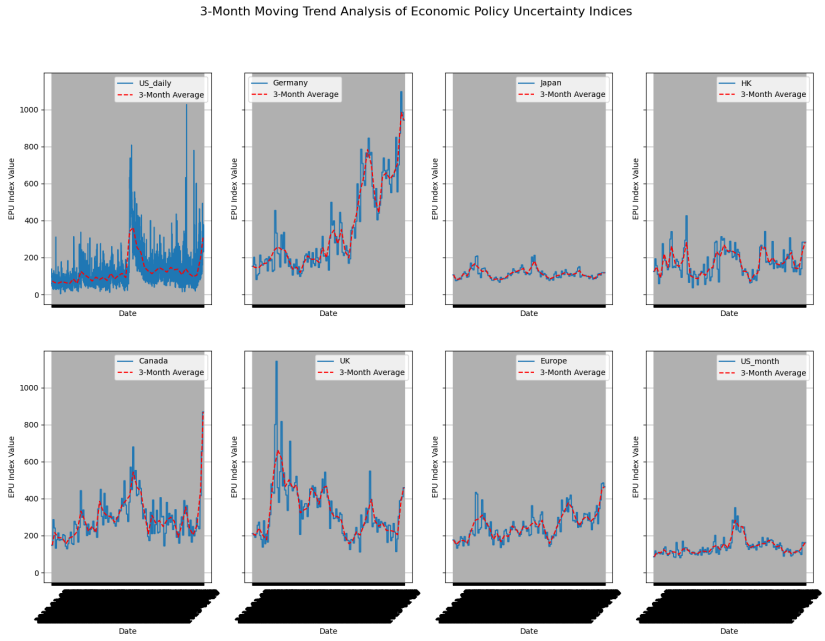


Figure 6: Moving Trend Analysis of Economic Policy Uncertainty Indices

- **Forward Contracts:** Forward contracts serve as a cost-effective means of mitigating exchange rate fluctuations by locking in future currency exchange rates. Unlike options, forwards provide full coverage against adverse exchange rate movements but do not allow for participation in favorable rate shifts.

The subsequent section will delve into the technical details of these hedging instruments, outlining their effectiveness in managing the risks associated with carry trades. By incorporating these hedging approaches, investors can enhance the stability of returns while minimizing exposure to macroeconomic shocks.

8 Forward Hedging Analysis

Carry trade strategies inherently expose investors to foreign exchange (FX) risk due to fluctuations in exchange rates. To mitigate this risk, we think that forward contracts can be used as a hedging mechanism, effectively locking in future exchange rates rather than relying on the spot rate at settlement. This section evaluates the effectiveness of forward hedging within a carry trade strategy.

8.1 Mathematical Framework

The total return of a carry trade strategy without hedging can be expressed as:

$$PNL_{\text{unhedged}} = A \times S_T - A \times S_0 \tag{11}$$

where:

- A is the notional amount in the investment currency.
- S_T is the spot exchange rate at time T (settlement date).
- S_0 is the initial spot exchange rate.

With forward hedging, an investor locks in a forward rate F determined at $t = 0$. The hedged return is then:

$$PNL_{\text{hedged}} = A \times F - A \times S_0 \tag{12}$$

The difference between the hedged and unhedged PnL is:

$$\Delta PNL = A \times (F - S_T) \tag{13}$$

The effectiveness of the hedge depends on how accurately the forward rate F captures the future spot movement. If F is an unbiased predictor of S_T, hedging should reduce volatility without significantly impacting expected returns.

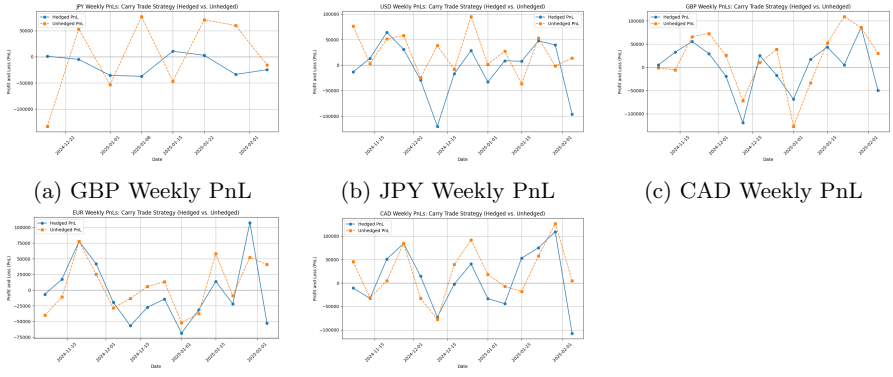
8.2 Empirical Results and Comparison

The forward hedging strategy was implemented across multiple currency pairs. Below, we compare the cumulative PnL of the carry trade with and without forward hedging.

Currency Pair	Unhedged PnL	Hedged PnL
GBP	248,956.59	23,934.80
JPY	11,497.62	-122,040.48
USD	345,474.41	-70,261.75
DEM	81,381.60	-41,915.89
CAD	304,943.04	123,698.76

Table 2: Comparison of Cumulative PnL: Hedged vs. Unhedged Carry Trade

From Table 2, we observe that **in all cases, forward hedging yielded lower or even negative PnL compared to the unhedged strategy**. This indicates that while forward contracts reduce FX risk, they also eliminate potential gains from favorable currency movements.



(a) GBP Weekly PnL (b) JPY Weekly PnL (c) CAD Weekly PnL

(d) USD Weekly PnL (e) HKD Weekly PnL

Figure 7: Comparison of Weekly PnL for Hedged vs. Unhedged Carry Trade

8.3 Graphical Analysis

To further illustrate the impact of forward hedging, Figure 7 presents the weekly profit and loss (PnL) for each currency pair.

The plotted results confirm that in most cases, the **unhedged strategy exhibits higher fluctuations but ultimately outperforms the hedged strategy in cumulative PnL**. This is especially evident in **JPY and USD**, where forward hedging led to substantial losses.

8.4 Key Takeaways

- Forward hedging **effectively eliminates FX risk but at the cost of potential gains**. The reduction in volatility does not necessarily translate into higher returns.
- The observed **negative PnL in some hedged cases (e.g., JPY, USD)** suggests that forward rates tend to overestimate actual depreciation.
- The hedging effectiveness **varies by currency pair**, highlighting the importance of currency-specific dynamics in determining hedging strategy effectiveness.

8.5 Conclusion

The analysis of CHF-funded carry trades across multiple currencies (CAD, EUR, GBP, JPY, USD) reveals that forward hedging does not always effectively reduce volatility or limit downside risk. In some cases, hedging with forwards results in higher risk exposure and negative PnLs due to unfavorable forward rate adjustments. Additionally, hedging eliminates potential upside gains when FX rate movements favor the carry trade.

A more flexible approach is to use options contracts for risk management. By purchasing call or put options, traders pay a premium but retain the ability to profit when FX rate movements are favorable. If FX rates move against the carry trade, the option provides a safety net to hedge potential losses, while if the rates move in favor of the trade, the trader can let the option expire and still capture gains.

This strategy offers a more dynamic risk management solution, allowing traders to benefit from positive FX shifts while limiting downside risk, unlike forwards which lock in rates regardless of market movement.

9 Hedging with USD/CHF Options

9.1 The Scenario Carry Trade Setup

We borrow in CHF (funding currency) at a low interest rate and invest in other currencies (like USD, EUR, GBP) that offer higher yields. Our profit depends on both the interest rate differential and stable or favorable FX movements.

9.2 FX Risk

If CHF strengthens, the value of foreign-currency assets (when converted back to CHF) falls. For example, if we have USD assets and USD/CHF (CHF per USD) declines because CHF is strong, our CHF-denominated returns are reduced. To hedge against the risk of a strong CHF (i.e., a decline in the USD/CHF exchange rate), we can buy a **put option on USD/CHF**. This option gives us the right, but not the obligation, to sell USD at a predetermined rate (strike price, K). If CHF strengthens and the spot rate S (CHF per USD) falls below K, our put option will be "in the money" and its payoff will help offset the losses on our carry trade.

9.3 Underlying Logic

1. **Without the Hedge:** Suppose we have an asset with a notional value of A USD. Its value in CHF at time T is:

$$\text{Value}_{\text{unhedged}} = A \times S_T \tag{14}$$

   where S_T is the spot USD/CHF rate at maturity.

2. **With the Hedge (Buying a Put Option):** We buy a European put option on USD/CHF with strike K and maturity T. The option's payoff per USD is:

$$\text{Payoff}_{\text{option}} = \max(K - S_T, 0) \tag{15}$$

   If we hedge the entire A USD exposure, our combined CHF value becomes:

$$V = A \times S_T + A \times \max(K - S_T, 0) \tag{16}$$

This can be written piecewise as:

$$V = \begin{cases} A \times S_T, & \text{if } S_T \geq K, \\ A \times K, & \text{if } S_T < K. \end{cases} \tag{17}$$

9.4 The Cost of Hedging – Option Premium

The premium for the put option (using a version of the **Garman-Kohlhagen model for FX options**) is given by:

$$P = Ke^{-r_f T} N(-d_2) - S_0 e^{-r_d T} N(-d_1) \tag{18}$$

where:

- S_0 is the current USD/CHF spot rate,
- K is the strike,
- r_d and r_f are the domestic and foreign risk-free rates,
- σ is the volatility,
- T is the time to maturity,
- $N(\cdot)$ is the cumulative distribution function of the standard normal distribution,
- and $d_1 = \frac{\ln(S_0/K) + (r_f - r_d + \sigma^2/2)T}{\sigma\sqrt{T}}, \quad d_2 = d_1 - \sigma\sqrt{T}.$

This premium is a cost that reduces the net carry yield but provides protection against a strong CHF.

9.5 Summary of the Hedge

Objective: Protect the value of our USD (or other foreign currency) assets in CHF terms if CHF appreciates.

Hedge Instrument: A put option on USD/CHF with strike K.

Hedged Value:

- If $S_T \geq K$: We get $A \times S_T$ CHF.
- If $S_T < K$: We get $A \times K$ CHF.

Trade-off: The option premium P is the cost of hedging, which reduces our net profit from the carry trade, but it limits downside risk if CHF becomes very strong.

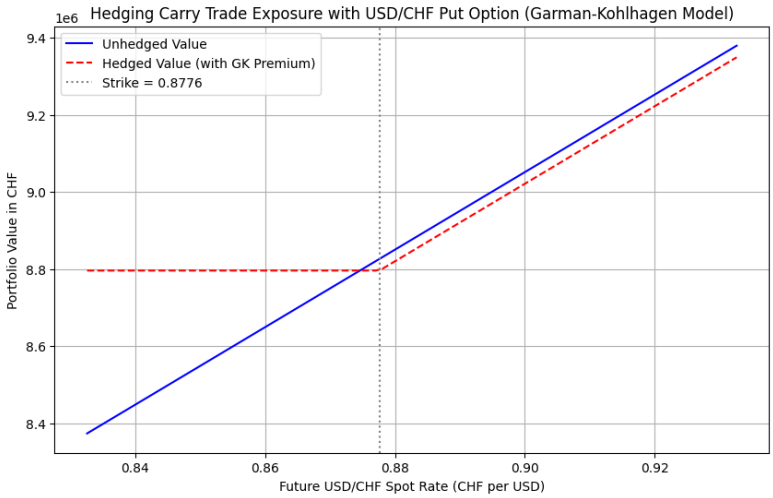


Figure 8: Hedging Carry Trade Exposure with USD/CHF Put Option (Garman-Kohlhagen Model)

9.6 Hedging Effectiveness Analysis

To evaluate the impact of using a USD/CHF put option, we simulate a range of possible future exchange rates S_T and compare the portfolio value under hedged and unhedged scenarios. Figure 8 illustrates the outcomes.

Key Observations:

- When $S_T \geq K$, the put option expires worthless, and the hedged portfolio performs slightly worse than the unhedged portfolio due to the premium paid.
- When $S_T < K$, the put option is exercised, ensuring a minimum CHF value for our USD exposure, effectively capping losses.
- The trade-off is between downside protection and the cost of purchasing the option.

9.7 Direct vs. Indirect Hedge

Direct Hedge: If we have exposure in USD (i.e., we lend in USD), a put option on USD/CHF directly protects us against a strong CHF.

Indirect (Cross) Hedge: For currencies such as EUR or GBP, our risk is measured by the EUR/CHF or GBP/CHF rate. While these rates might be correlated with USD/CHF, the relationship isn't one-to-one. We could use a USD/CHF option to hedge some of the exposure if, for example, the USD acts as a proxy for overall CHF strength.

However, this is an imperfect hedge because:

1. The correlations may not be stable.

2. The dynamics (volatility, skew, etc.) of EUR/CHF or GBP/CHF can differ from those of USD/CHF.

The hedge ratio can be estimated using the correlation between the changes:

$$\text{Hedge Ratio}_i = \frac{\text{Cov}(\Delta S_{\text{USD/CHF}}, \Delta S_{i/CHF})}{\text{Var}(\Delta S_{\text{USD/CHF}})} \tag{19}$$

where i represents the foreign currency being hedged.

9.8 Key Considerations

- **Correlation Analysis:** Need to analyze historical correlations between USD/CHF and the other currency pairs to set the right hedge ratios.
- **Volatility and Skew Differences:** The implied volatility and skew of options on different currency pairs can differ.
- **Dynamic Hedging:** Since correlations can change over time, the hedge ratio may need frequent adjustments.

9.9 Summary

With T = 1 week, we gain near-term downside protection. Premiums are usually lower than for a multi-month hedge, and are aligning with our carry trades expiry. $K = S_0$ - 0.005 means we only hedge beyond a 0.005 drop in USD/CHF. This reduces premium cost but provides a partial hedge (a "knock-in" effect at that level).0.005 is a threshold we get after analyzing the exchange rate volatility. If CHF strengthens significantly below K, the put payoff can prevent large FX losses. If USD/CHF stays above K, we lose only the premium. Compare to Doing Nothing, the chart will show that once S_T dips below K, the hedged PnL (red line) is higher than the unhedged (blue line). For above K, the hedged line is slightly lower by the premium cost.

10 Conclusion

In this study, we examined a quantitative carry trade strategy funded by the Swiss franc (CHF), integrating macroeconomic uncertainty considerations and hedging mechanisms using both forward contracts and options. Our empirical findings indicate that while the traditional, unhedged carry trade can generate substantial returns during stable market conditions, it remains vulnerable to adverse currency movements and sensitive to macro environment. Forward hedging largely neutralized FX risk but often eliminated upside potential and suffer cost of entering to the forward, whereas option-based hedging demonstrated a more flexible balance between risk mitigation and profit preservation.

While the current strategy integrates macroeconomic uncertainty analysis and employs forward contracts and options for hedging, additional enhancements can refine risk management and optimize returns. In particular, dynamic hedging strategies, where hedge ratios respond to real-time changes in implied volatility and macroeconomic forecasts like evolving central bank policy expectations.

Incorporating machine learning models to anticipate macroeconomic shocks and regime shifts could also enhance trade timing and position sizing, thus improving risk-adjusted returns. By analyzing historical data on interest rate decisions, inflation reports, and geopolitical risks, such models could forecast adverse market movements and offer early warning signals. These insights could guide the optimal timing for initiating forward contracts or options, particularly during periods of elevated market uncertainty, including unexpected central bank interventions or geopolitical events that influence currency valuations.

Overall, this approach confirms the viability of CHF-funded carry trades, provided that currency exposures are managed with adaptive hedges and closely monitored macroeconomic indicators. Incorporating these techniques can help practitioners better navigate periods of market stress, minimize drawdowns, and preserve gains in an ever-shifting global FX environment and serves as a starting point for developing a more robust FX carry trade strategy.

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