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Assignment 2

Carry Strategy:

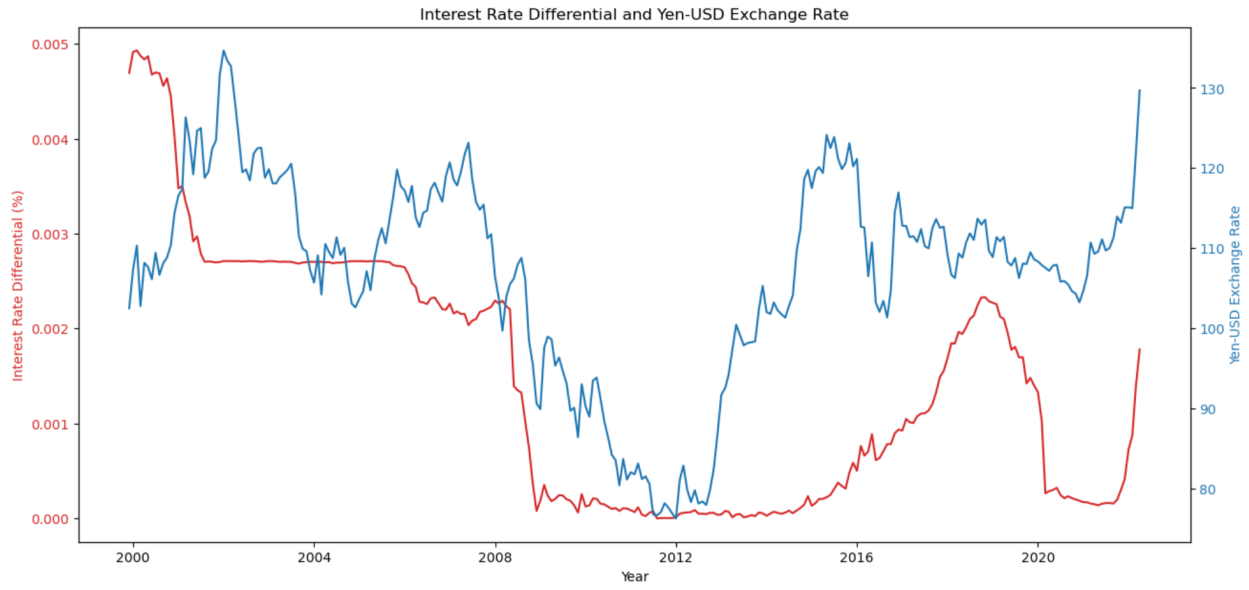
Carry strategy is a strategy in which an investor borrows a currency with a low interest rate and uses the funds to invest in a currency yielding a higher interest rate, amining to profit from the interest rate differential between the two currencies. The profitability is primarily dependent on the relative movement of interest rates and exchange rates.

Example of Traditional Carry Strategies:

Japanese Yen Carry Trade: One of the most famous examples of a carry trade over the past two decades has been the Japanese Yen carry trade. Investors would borrow in Japanese yen, which often had very low-interest rates, and invest in currencies with higher yields like the Australian Dollar or U.S. Dollar. The interest rate differential provided a profit margin. [This strategy was recently in news when Berkshire Hathaway during covid borrowed funds from Japan at 0.5% to invest in companies that offered higher dividend yield of about 5%]

U.S. Dollar and Emerging Market Currencies: Another common carry strategy involved borrowing in U.S. dollars, especially when U.S. interest rates were low, and investing in emerging market currencies that offered higher interest rates. This was particularly prevalent when the Federal Reserve implemented quantitative easing, keeping U.S. rates low.

Rise & Fall of ¥-$ carry trade:



Interest Rate Differential (Red Line) shows the difference between the interest rates in US and Japan over time. Higher value indicates that US interest rates are higher than those in Japan making the carry trade more attractive, conversely, a lower or negative value suggests less advantage or no advantage engaging in the carry trade.

Yen-USD Exchange Rate (Blue Line) shows the exchange rate between Japanese Yen and dollar over time. Rising line indicates that the Yen is strengthening against the Dollar, which is generally unfavorable for the Yen-USD carry trade, whereas falling line means Yen is weakening, which can be favorable for the carry trade.

Looking at trend over years:

Late 1990s to Mid-2000s: During this period, we observe a relatively high interest rate differential favoring the US dollar over the yen, indicating that this period can be a favorable environment for the Yen-USD carry trade, as investors could benefit from the interest rate gap.

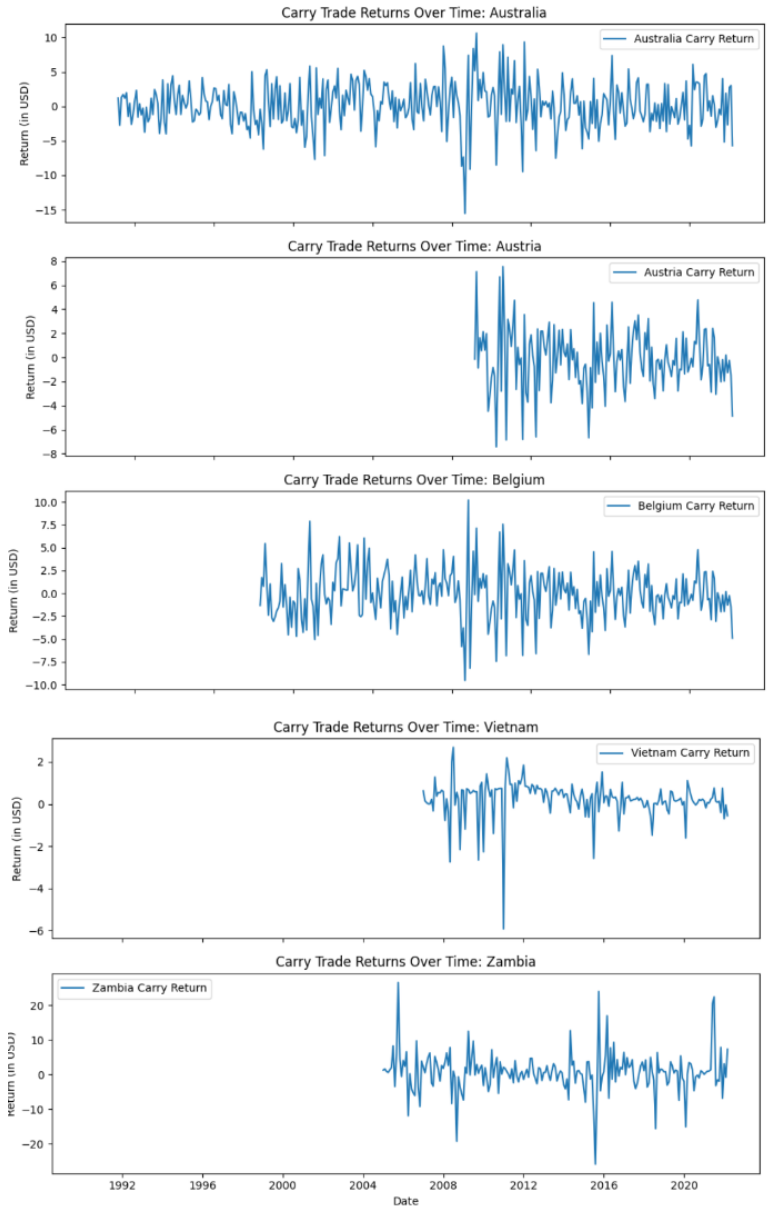
Global Financial Crisis (2007-2009): This period is marked by significant fluctuations in the exchange rate and a narrowing interest rate differential. The crisis likely led to increased volatility and risk, making the carry trade less attractive.

Post-2009: After the financial crisis, the interest rate differential remains low, reflecting the global trend of low interest rate, exchange rate also shows increased volatility. The carry trade during this period would have been less profitable and more risky due to lower interest differentials and exchange rate uncertainties.

Recent Years: The interest rate differential appears to widen again in more recent years, which could indicate a resurgence in the attractiveness of the carry trade.

Time Series:

The picture below shows the time series of the monthly carry strategy for 5 of the countries in the list, to better understand the behavior/pattern of the strategy over the time period.



Summary Statistics:

The table below shows the mean annualized carry return and the annualized carry standard deviation (risk) for the first 30 countries in the list.

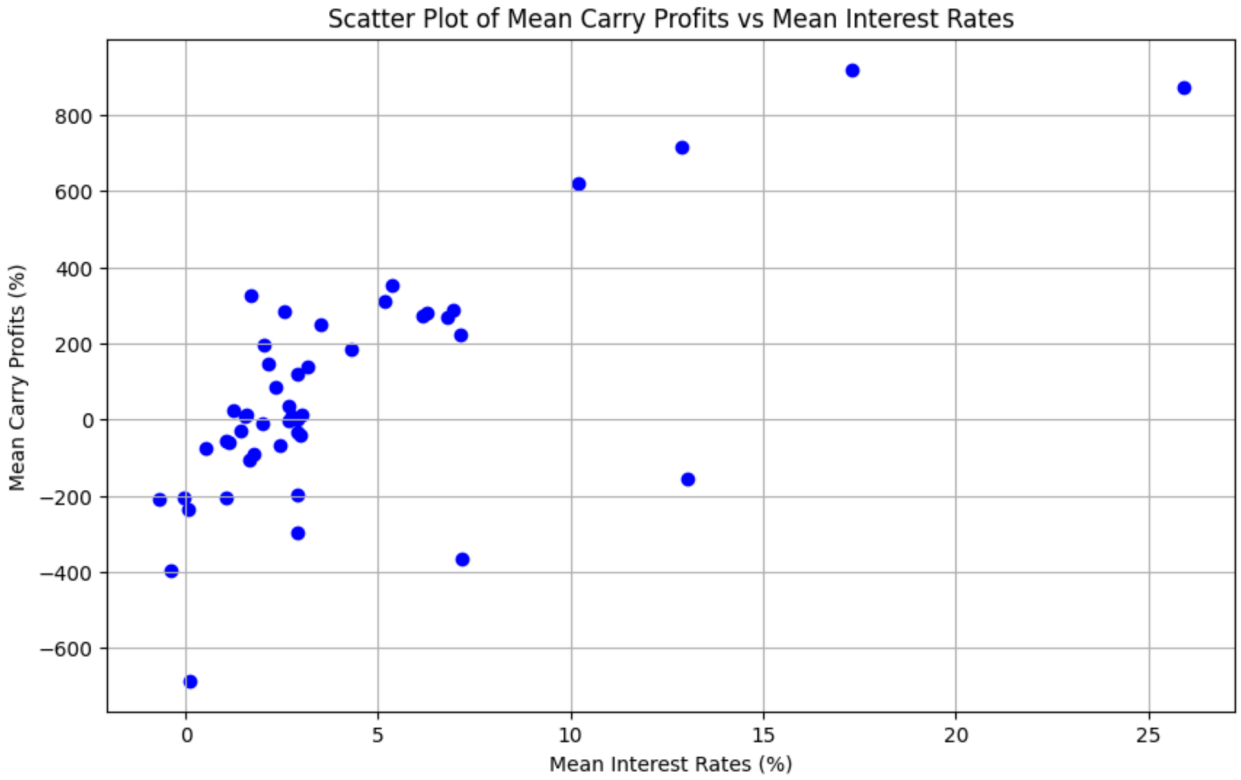
country	MeanAnnualizedCarryReturn	AnnualizedCarryRisk	SharpeRatio
Australia	1.856097e+02	1138.137729	0.163082
Austria	-2.050078e+02	881.314589	-0.232616
Belgium	-2.896708e+01	952.389498	-0.030415
Brazil	7.169546e+02	1722.483839	0.416233
Bulgaria	-2.053935e+02	976.705571	-0.210292
Canada	8.427732e+01	850.233292	0.099123
Chile	-2.964269e+02	1169.650130	-0.253432
China	2.819491e+02	338.690818	0.832468
Colombia	2.722876e+02	1316.418742	0.206840
Croatia	-6.078583e+01	738.330009	-0.082329
CzechRepublic	3.263000e+02	1178.704596	0.276829
Denmark	1.141682e+01	959.469364	0.011899
EuroArea	-8.977120e+01	944.822993	-0.095014
Finland	-3.956799e+02	715.458675	-0.553044
France	8.845527e+00	978.204467	0.009043
Germany	-1.045783e+02	953.317104	-0.109699
HongKong	-1.207469e+01	58.425665	-0.206668
India	2.675586e+02	703.337822	0.380413
Indonesia	2.868668e+02	956.839709	0.299807
Ireland	6.914526e+00	944.801817	0.007318
Italy	-2.648632e+00	927.439841	-0.002856
Japan	-2.358803e+02	928.517691	-0.254040
Kenya	6.218873e+02	596.881654	1.041894
Malaysia	1.197100e+02	717.631998	0.166813
Mexico	2.215628e+02	1103.640208	0.200756
Netherlands	-5.688383e+01	165.993118	-0.342688
NewZealand	3.116203e+02	1138.845931	0.273628
Norway	-4.017988e+01	1106.214171	-0.036322
Pakistan	-6.861357e+02	552.269931	-1.242392
Peru	3.417688e+01	607.791424	0.056231
Philippines	3.540161e+02	557.695812	0.634783

When looking at the entire table, we can see that Zambia is the best performing country and Pakistan is the worst performing country in terms of mean carry returns.

Do higher interest rate countries provide higher carry?

To answer this we regressed the mean carry returns on mean interest rates across 48 countries, the slope coefficient will indicate if a higher interest rate is associated with higher carry profits.

The scatter plot below gives a brief overview of the correlation between these two variables; mean carry profits and mean interest rates for each country



The regression results as given below have a few key results that need to be analyzed. Like:

- R-squared: A 52.2% r-squared implies that around 52% of the variance in the mean carry profits is explained by the mean interest rate.
- Slope Coefficient: The coefficient for mean interest rates is approximately 45.37. This implies that for each percentage point increase in the mean interest rate, the mean carry profit increases by about 45.37 percentage points.
- P-Value: The p-value for the slope coefficient is significantly small (less than 0.01), suggesting that the relationship between mean interest rates and mean carry profits is statistically significant.

OLS Regression Results

Dep. Variable:	MeanCarryProfits	R-squared:	0.522
Model:	OLS	Adj. R-squared:	0.512
Method:	Least Squares	F-statistic:	50.29
Date:	Mon, 20 Nov 2023	Prob (F-statistic):	6.65e-09
Time:	17:28:54	Log-Likelihood:	-324.39
No. Observations:	48	AIC:	652.8
Df Residuals:	46	BIC:	656.5
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-115.1136	40.436	-2.847	0.007	-196.507	-33.720
MeanInterestRates	45.3720	6.398	7.091	0.000	32.493	58.251

Omnibus:	16.142	Durbin-Watson:	2.017
Prob(Omnibus):	0.000	Jarque-Bera (JB):	19.381
Skew:	-1.228	Prob(JB):	6.19e-05
Kurtosis:	4.913	Cond. No.	8.41

According to UIP, the interest rate differential between 2 countries should be offset by the expected change in exchange rates. Thus, there should be no systematic opportunity to earn profits from carry trades if UIP holds. However, as per the regression, i.e. the positive and significant slope coefficient suggest that higher interest rates are associated with higher carry profits. This evidence can be interpreted as a violation of the UIP theory, as it implies the existence of systematic profits from carry trades. Indicating that countries with higher interest rates tend to offer higher carry returns, this deviation could be due to various market inefficiencies, risk premiums or other factors not accounted for by UIP.

Carry Portfolios:

Please find the screenshot below of the different portfolios created.

	year	month	portfolio	NetCarryReturnAdjusted
0	1991	1	1.0	-7.865822e-09
1	1991	1	4.0	-2.975436e+00
2	1991	1	8.0	5.397727e-01
3	1991	2	1.0	7.869161e-09
4	1991	2	4.0	-9.575660e+00
...	...	...	...	...
2827	2022	3	4.0	-3.462497e+00
2828	2022	3	5.0	-3.405226e+00
2829	2022	3	6.0	-3.791441e+00
2830	2022	3	7.0	-2.621794e+00
2831	2022	3	8.0	1.807598e+00

Carry-β:

This is the table generated and followed is the explanation of it:

	Portfolio	Intercept (a_p)	Carry-Beta (beta_p)	R-squared
0	1.0	-0.118180	-1.824141	0.002928
1	4.0	0.042010	-5.478504	0.009714
2	8.0	0.356270	7.973021	0.019596
3	3.0	-0.022404	-4.828386	0.008156
4	6.0	0.130243	-1.612949	0.001071
5	2.0	-0.059543	-2.480336	0.002780
6	5.0	0.161516	-2.588462	0.003095
7	7.0	0.116915	0.974372	0.000337

Intercept represents the average monthly carry profit for the portfolio when the market excess return (mktrf) is zero.

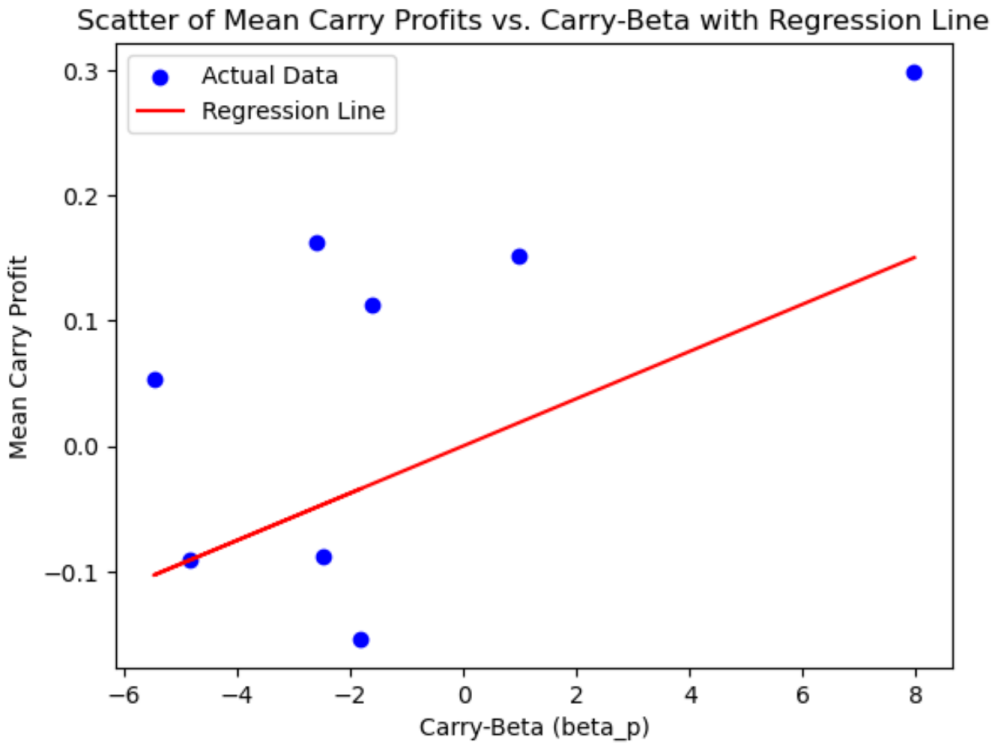
Carry-Beta is the regression coefficient for the market excess return. It measures how sensitive the portfolio's carry profit is to the changes in US market excess returns. Positive beta indicates that the portfolio's carry profit tends to move in the same direction as the market excess return, a negative beta indicates an inverse relationship. Example for portfolio 1, it implies a negative relation between the portfolio's carry profits and the excess market return.

As per the construction of the portfolios, portfolio 1 has the lowest interest rate while portfolio 8 has the highest interest rate countries. When comparing portfolio 1 and 8 specifically it is apparent that higher interest-rate portfolios have higher carry-β, however when looking at all of

the portfolios this trend isn't as straightforward for example portfolio 2 and 3 have higher carry-β than portfolio 4.

Price of Carry-β:

The regression line in the scatter plot shows the predicted relationship according to the regression model; how closely the portfolios align with the regression line can give insight into the accuracy of the model. If the points are close to the line, it suggests that the model's predictions are consistent with the actual data.

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Theta (Coefficient): 0.018844011149884297
R-squared: 0.24990484427316728
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The annualized theta is 0.2262.

The coefficient theta represents the slope of the regression line, indicating how much the mean carry profit is expected to change for each unit change in carry- β. In our case of positive theta it suggests that portfolios with higher carry - β (which shows greater sensitivity to US market excess return) are associated with higher mean carry profits.

The R-squared value measures the proportion of the variance in mean carry profits that is predictable from carry- β. A higher R-squared value indicates that a larger proportion of the variance in mean carry profits is explained by carry- β, suggesting a stronger model fit. A lower R-squared value indicates that other factors not included in the model might also be influencing the mean carry profits.

As per our finding of the value of theta conclude to be positive and although the points on the graph do not closely align with the regression line, it supports the theory. The actual carry returns somewhat closer to prediction of the theory.

Why in theory do we expect λ > 0?

Risk Compensation Investors engage in carry trades by borrowing in currencies with low interest rates and investing in currencies with higher rates. The positive theta in this context would represent the risk premium investors require for the risks they take on, which include:

- Interest Rate Risk: Changes in differential interest rates can affect the return on the carry trade.
- Exchange Rate Risk: Fluctuations in currency exchange rates can erase profits from interest differentials.
- Liquidity Risk: The ability to unwind carry trade positions without significant cost is a concern, especially in volatile markets.
- Geopolitical and Economic Risks: Unexpected economic or political events can lead to sudden shifts in currency values.

To sum up, the expectation of theta>0 is predicated on the idea that carry trade profits incorporate a risk premium above and beyond the risk-free rate as recompense for the many kinds of financial risks that investors assume. Because the carry trade might result in losses when these risks materialize, it is regarded as a risk-bearing strategy rather than a chance for arbitrage.

INR Undervaluation?

As per our calculations, India's carry beta is 0.427. We also estimated the expected annual carry profit for India to be 0.0965 compared with the actual average annual carry profit for India is 2.676 which suggests that the Indian Rupee is potentially undervalued.