

Purchasing Power Parity Strategy in Trading Forex

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Abstract: Purchasing Power Parity (PPP) strategy has been implemented in the foreign currency exchange market for many years. The crucial basis for this strategy is the equilibrium of the purchasing power and disproportionate exchange rate. However, previous research has generally determined the profitability of the PPP strategy but has ambiguous signal generations, as PPP is data released annually. Thus, the repeatability of the research is low. In this paper, we use data including CPI, PPP, interest rate, market exchange rate, bid-ask spread, and DXY between January 1, 1997, to August 1, 2022, to generate a dynamic relatively purchasing power parity, which is a monthly data, and then generate our signal and test the feasibility and profitability of our research. Our finding, including the in-sample and out-of-sample tests, indicates that, RPPP could be an effective forex trading strategy. Furthermore, in the long run, the PPP strategy based on our signal is profitable, and the loss is acceptable.

Keywords: PPP, RPPP, FX trading, inflation rate, repeatability, profitability, loss

1. Introduction

The PPP strategy compares different countries' currencies through a "basket of goods" approach and determines whether a currency is overvalued or undervalued based on another currency [1,2]. On 2022 August 5th, We first heard about this strategy from Professor Eric Yeh in his class.

1.1. Economic Intuition

Purchasing power parity (PPP) strategy is a value strategy used in the Forex market. It measures prices at different locations based on the law of one price, which means that if there are no transaction costs or trade barriers for a particular good, then the price for the good should be the same at every location [1]. We compare each currency's PPP to the market exchange rate based on one currency and use the ratio to determine whether a currency is overvalued or undervalued, then short most overvalued currencies and long most undervalued currencies.

1.2. Literature Review

Purchasing power parity (PPP) strategies have been implemented in foreign exchange markets for many years. The essential foundations of this strategy are the equilibrium of purchasing power and disproportionate exchange rates [1]. Previous studies have generally determined the profitability of PPP strategies, but since PPP is an annual data release, its signal algebra is unclear. To maintain the frequency of transactions, a dynamic relative PPP is needed. However, the current research on RPPP is not very comprehensive, and there are few definitions and trading examples of actual RPPP generation. In this study, according to the definition of RPPP, by combining PPP data with RPPP data, the team tried to convert the annual data into monthly dynamic data to improve the transaction frequency.

1.3. Signal Generation

First, we use annualized monthly inflation rate to calculate the monthly inflation rate. The next step is to generate a monthly dynamic coefficient D based on the monthly inflation rate of the trading currency country and China. Then, based on the yearly PPP data and dynamic coefficient, a monthly RPPP value could be calculated [3]. Finally, we get the Real Exchange Rate by taking the ratio of the RPPP rate versus the market exchange rate. The Real Exchange Rate minus one is our Signal.

1.4. Portfolio Construction

Every month, we rank our signals from largest to smallest. In short, the currency corresponds to the three most significant signal values, long the currencies correspond to the smallest three signal values. The rebalance frequent is monthly. 16.66% of the total notional (16.66 million) is allocated to each of the six selected currencies in G10.

Table 1: Evaluation.

	Annualized Return	Volatility	Maximum Drawdown	99% VaR	99% ETL	Information Ratio (benchmark return=0)	Information Ratio (based on DXY)
Expectation	1.20%	1.00%	-4.00%	-1.50%	-2.00%	1.2	1.3
Actual result	2.53%	1.19%	-5.55%	-2.53%	-3.01%	2.13	2.19

2. Analysis

2.1. Economic Intuition

PPP (purchasing power parity) is a way to compare the value of baskets of goods and services across different countries at a given point in time. Compared with the price in the reference country, the prices of the product in different countries may be higher or lower than the reference price when converting the domestic prices into the same currency of the reference country by exchange rate. Therefore, longing the currencies with lower value and shorting the currencies with higher value to earn the profit seems reasonable because the actual prices of goods and services anywhere in the world in the long run tend to be the same due to the arbitrage opportunity, which is achieved by

purchasing the asset at a lower price and then sell it at a higher price influenced by the interest rate, inflation, and exchange rate.

2.2. Quantitative

To evaluate the strategy, this research would calculate the annualized return, Sharpe ratio, volatility, 99%Var, 99%ETL, and largest peak-to-trough drawdown. Monthly data generate the statistics.

2.3. Data

2.3.1. Universe: G10 currencies

G10 currencies are ten of the most liquid currencies all around the world. On the one hand, the more liquid the market, the lower the cost of conducting immediate transactions. On the other hand, in an illiquid market, it is hard to manage risk if the trader is on the wrong side of a big move [4]. G10 currencies include the British Pound (GBP), Euro (EUR), Japanese Yen (JPY), Swiss Franc (CHF), United States Dollar (USD), Canadian Dollar (CAD), New Zealand Dollar (NZD), Australian Dollar (AUD), Norwegian Krone (NOK) and Swedish Krona (SEK) [5]. The paper aims to trade G10 currencies with CNY.

2.3.2. Data sets

For signal generation and portfolio construction:

- i. Yearly PPP data (USD Base)
- ii. Inflation rate (Converted from OECD monthly CPI data / We use the data of EA19 instead of European Union, as some members of the European Union do not use the single currency)[6]
- iii. Market exchange rate of G10 currencies (CNY Base)

For Transaction costs:

- iv. Monthly interest rates (Based on OECD short-term interest rate/ Since Japan does not have short-term interest rate data before 2002 and China does not have short-term interest rate data before June 1997, we use the long-term interest rate as an estimation to replace these blank parts)[7]
- v. The bid-ask spread of G10 currencies

For Summary statistics

- vi. DXY data (as a benchmark return for calculating the Information ratio)

All data has been downloaded and stored as CSV files.

2.3.3. Data source

- i. The OECD Purchasing Power Parity data is downloaded from <https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm>.
- ii. The CPI data is downloaded from <https://data.oecd.org/price/inflation-cpi.htm>
- iii. The market exchange rate is downloaded from <https://www.investing.com/currencies/>
- iv. The annual interest rates are obtained from <https://data.oecd.org/interest/long-term-interest-rates.htm#indicator-chart>.
- v. The bid-ask spread is obtained from <https://www.investing.com/currencies>
- vi. The DXY data is downloaded from <https://www.investing.com/currencies/us-dollar-index-historical-data>

2.3.4. Data range

Purchasing power parity is a theory concerning the long-term equilibrium exchange rates based on the relative price level of two countries. The Period of Rebalancing is monthly. In order to guarantee the research capacity, during the research, our test starts from January 1, 1997, to August 1, 2022. The starting date of the test is limited by the earliest publication date of OECD Inflation Rate Data for the Euro Area. The sample test period is from January 1, 1997, to January 1, 2017 [8]. Of sample, test period is from January 1, 2017 to August 1, 2022.

2.4. Strategy Detail

2.4.1. Signal Generation

Because PPP is a yearly data, to maintain the accuracy and frequency of trading data, we create a dynamic RPPP (relative purchasing power parity) through CPI data to predict the trends [9,10]. By taking the ratio of the RPPP rate versus the market exchange rate, we obtain the Real Exchange Rate (RER), which should equal 1 if the market rate equals the PPP value. A RER that is above 1 means the currency is undervalued. A RER value that is below one means that the currency is overvalued. In the paper, S is used to represent the signal.

First, we use annualized inflation rate that is published monthly to calculate the monthly inflation rate (I) [11]

$$I = (1 + \text{annualized inflation rate})^{1/12} - 1$$

The next step is to generate a monthly dynamic coefficient D based on the monthly inflation rate of the trading currency country and China.

$$D = (1 + I \text{ of currency country}) / (1 + I \text{ of china})$$

$$D_n = D \text{ based on inflation rate data of the } n\text{th month}$$

Based on the yearly PPP data and dynamic coefficient, a monthly RPPP value could be calculated,

$$\text{RPPP for January} = \text{PPP}$$

$$\text{RPPP for February} = \text{RPPP for January} * D1$$

$$\text{RPPP for March} = \text{RPPP for February} * D2$$

...

$$\text{RPPP for December} = \text{RPPP for November} * D11$$

Noticing that the PPP data we have is USD base, we need to transform it into a CNY base,

$$\text{PPP yearly data (CNY)} = \text{PPP yearly data (USD)} / \text{China PPP yearly data (USD)} [12]$$

By taking the ratio of the RPPP rate versus the market exchange rate, we obtain the Real Exchange Rate (RER)

$$\text{RER} = \text{RPPP} / \text{Exchange Rate}$$

The signal S is defined by

$$S = \text{RPPP} / \text{Exchange Rate} - 1$$

The predicted return is

$$(\sum |S - \text{Exchange rate}| / \text{Number of Currencies}) * \text{Capital}$$

It is the mean value of the difference between the real exchange rate and the exchange rate for FX in the universe multiplied by the capital.

2.4.2. Portfolio construction

$$S_n = S \text{ ranks } n\text{th}$$

$$C_n = \text{The currency that } R_n \text{ corresponds to}$$

A total of 100 million CNY is used for trading. The rebalancing frequency is monthly. In each month, we pick six currencies. C1, C2, and C3 from the G10 to go short. C8, C9, and C10 from the G10 to go long. 16.66% of the total notional (16.66 million), is allocated to the six selected currencies in G10. For C1, C2, C3, shorting using 16.66 million CNY. For C8, C9, C10, longing using 16.66 million CNY.

2.4.3. Trade Execution

Trade execution must consider bid-ask spreads (0.015% for each trade) and interest rates when trading forex. In forex trading, the transaction cost mainly comes from the bid-ask spread. This study used fixed bid-ask spreads for each currency during the test period [13]. When holding G10 currencies in long positions, currency holders can earn interest from depositing banks. When holding G10 currencies in short positions, traders would hold CNY until returning the borrowed money and thus get paid interest from the Chinese bank. The borrowing rate is not considered here.

Realized PnL:

Note that when holding one or more currencies for more than a month, the bid-ask spread for those currencies is calculated only in the first month.

Long PnL = [(Market Price - Last month Market Price) / Last month Market Price] * Capital - bid-ask spread rate * number of rebalanced FX * 16.66million + monthly interest rate * Capital

Short PnL = [(Last month Market Price - Market Price) / Last month Market Price] * Capital - bid-ask spread rate * number of rebalanced FX * 16.66million - monthly interest rate * Capital

PnL = Long PnL + Short PnL

3. Implement

3.1. In- Sample PnL Result

Figure 1 shows the in-sample cumulative PnL graph, showing the monthly PnL during the in-sample period. The change in cumulative returns may be related to China's economic development. From the graph, the overall trend is upward with lots of fluctuations and slow upward movements at the end. From 1997 to 2012, the economy in China improved extremely fast; from 2012 to 2017, the growth rate of the Chinese economy got slower. The total money returned over twenty years is about ¥50,601,635. In the long run, the strategy is profitable, and the loss could be acceptable. In some years, there may be losses, but the amounts are small and acceptable, and the duration of the losses is relatively short. A relatively long-time drawdown occurred between 2011 and 2016, but the drawdown was small and returned to its peak in 2017. At the end of our in-sample test, an upward trend has emerged.

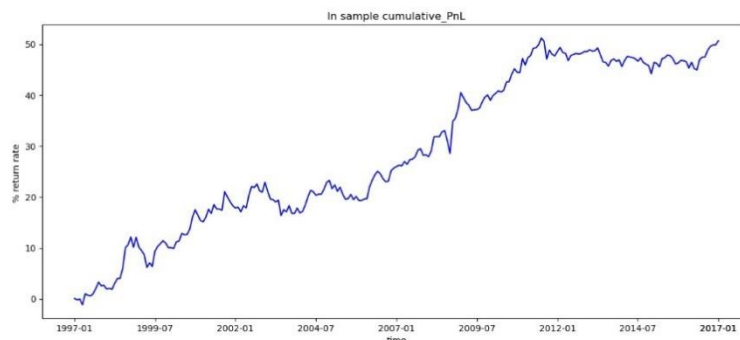


Figure 1: In-Sample cumulative PnL results.

3.2. In-Sample Summary Statistics

Note that the statistics we calculated are based on monthly results.

Table 2: Tale 1. In-Sample summary statistics.

Annualized Return	Volatility	Maximum Drawdown	99% VaR	99% ETL	Information Ratio(benchmark return = 0)	Information Ratio(based on DXY)
2.52%	1.19%	-5.55%	-2.53%	-3.01%	2.12	2.19

Table 2 shows that the annualized return is about 2.52%, which is not high. The volatility is 1.19%. The maximum drawdown is ¥5,550,000, -5.55% of the total. The 99% VaR is ¥ -2,530,000, about -2.53% of the total. It means the possibility of the largest loss within ¥ 2,530,000 is 99%. The 99% ETL is ¥ -3,010,000, about 3.01% of the total. It means the expected loss within ¥ 3,010,000 in 99% of the time. The information ratio is 2.12. Overall, the return and information ratio is good, and the strategy loss is well-controlled.

3.3. Difference from Expectation

Contrary to the expected statistics, the data from actual results are all higher. Therefore, the higher annualized return and information ratio inaccurate results mean more profits from this strategy, which indicates this strategy is more effective than we expected. On the other hand, when the volatility and maximum drawdown are higher and 99% VaR and ETL are lower, this strategy becomes riskier as the probability of losing more money is higher, and the trends are more volatile. Thus, the strategy shows more profitability and risks from the contrast between the expectation and the actual result.

4. Conclusion

4.1. Out-of-sample PnL Results

Figure 2 represents the out-of-the-sample cumulative PnL, which shows the monthly PnL during the out-the-sample period. The total money returned is around ¥7,756,200 during this period. With lots of fluctuations, the graph shows a downward trend in the first half but a much more significant upward trend later. This strategy was not quite profitable out of the sample period from the two opposite trends.

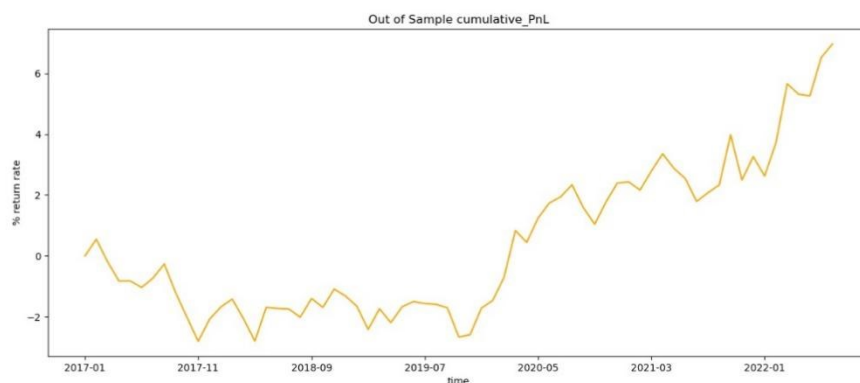


Figure 2: Out-of-Sample cumulative PnL results.

4.2. Out-of-Sample Summary Statistics

Note that the statistics we calculated are based on monthly results. Due to insufficient sample size, we calculate 90% VaR and 90% ETL here.

Table 3: Out-of-Sample summary statistics.

Annualized Return	Volatility	Maximum Drawdown	99% VaR	99% ETL	Information Ratio(benchmark return = 0)	Information Ratio(based on DXY)
1.39%	0.69%	-3.45%	-0.75%	-0.93%	2.02	2.05

The annualized return in our out-of-sample backtest is 1.39%, which is lower than the annualized return of the in-sample test. The volatility is 0.69%. The maximum drawdown is ¥3,700,000, which is -3.7% of the total. The 99% VaR is -0.75%, which is ¥ 750,000. It means the possibility of the largest loss within ¥ 750,000 is 99%. The 99% ETL is ¥ 930,000, about -0.93% of the total. It means the expected loss is within 930,000 99% of the time. The information ratio with DXY is 2.02. It is a great improvement to the PPP theory, which states that price differences between countries should narrow over time by the exchange rate movements or by different inflation rates. PPP is virtually useless in forecasting currencies over the short to medium term: currencies can remain overvalued or undervalued for long periods. While researching PPP data, we discovered that the Swiss franc had been overvalued over the dollar by more than 15% for decades.

4.3. Difference from Expectation

Compared with the expected data, the annualized return and information ratio from out-of-sample results are slightly higher, which shows more profits, but still lower than the in-sample result. The lower volatility, maximum drawdown, and higher 99% VaR and ETL show fewer risks with less possible, most significant, and expected loss. Overall, the out-of-sample result shows slightly more profits but much less risk.

4.4. Additional Consideration

4.4.1. Risk.

Interest Rate Risks:

In this strategy, the effect of interest rates on currency movements is not considered. If interest rates rise in a country, that country's currency strengthens because of a flood of investment into that country's assets, possibly because a rising currency brings higher returns. Conversely, if interest rates fall, that country's currency will weaken as investors start to pull back. Because of the nature of interest rates and their roundabout effect on exchange rates, differences between currency values can lead to sharp changes in foreign exchange prices [14].

4.4.2. Environment.

Country:

Instability in a country affects its currency. When an adverse event occurs, or when traders fear an adverse event, investors typically pull money out of a country's currency, and in doing so, it depreciates. It can happen quickly (i.e., during political turmoil) and lead to illiquid markets. Therefore, we chose to trade G10 Currency, which is not foolproof.

Policy:

A country deliberately lowers the value of its currency in order to compete more effectively in terms of trade. A weaker currency makes a country's exports less expensive in export markets. The strategy does not take this factor into account.

4.5. Trading Recommendation

4.5.1. Why we suggest PPP trading strategy to investors

PPP is a long-term fundamental indicator and the leading influencing factor in the forex market. We can rely on it to predict the future of the currency rates using the long-term horizon of several years. We get positive returns both in the sample and out-of-sample tests. Even if the annualized returns are not high, we still suggest this trading strategy to the investment firm and manager. PPP strategy is easy to implement, as G10 currencies are highly liquid on the forex market, and the bid-ask spread will not harm our return.

4.5.2. Long-term trading

Many other factors influence currency pairs. For example, trade balance, supply and demand, interest rates, and political stability affect currencies significantly. Therefore, to minimize the damage caused by other factors, we must avoid short-term and mid-term trading when following the PPP strategy. In addition, rebalance frequency should not be too high; a monthly adjustment is reasonable.

4.5.3. Potential improvement on the universe

The movement of G10 currencies may not accurately follow the PPP movement. Before constructing our portfolio, we could choose PPP data of twenty currencies countries, calculate the correlation between each currency's movement and the PPP movement, determine which currencies have the highest correlation, and use these currencies as our universe. Besides, we can expand our universe and choose twenty currencies instead of ten. The currency of the open world could also be taken into account. Note that some of the currencies we chose may not be as liquid as G10; the transaction costs are likely higher.

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