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Time-Series Analysis

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Introduction

This project aims to investigate the potential long-run relationship between the stock price of JPMorgan Chase & Co. (JPM) and the S&P 500 by testing for cointegration. We will manually estimate the cointegrating vector by regressing one variable on the other and testing the residuals for stationarity using the Augmented Dickey-Fuller test. By doing so, we aim to determine whether the two time series share a common stochastic trend. If cointegration is found to exist, we will estimate the long-run relationship between the variables and construct error correction models to analyze their short-term dynamics. Our primary research question is whether a stable long-term relationship exists between the stock price of JPM and the S&P 500, and whether this relationship can be used to inform investment strategies.

Analyzing the relationship between JPM's stock price and the S&P 500 is important for several reasons. Firstly, the S&P 500 is a commonly used benchmark for assessing the performance of the US stock market, and investors often compare the performance of their portfolios to this index. By understanding the relationship between JPM's stock price and the S&P 500, investors can assess how well JPM is performing relative to the overall market. Secondly, as JPM is a financial services company, its stock price may be influenced by broader trends in the financial sector. By comparing the performance of JPM to the S&P 500, investors can gain insights into the performance of the financial sector as a whole. Thirdly, some investors use the relationship between JPM's stock price and the S&P 500 to inform their trading strategies. Finally, the relationship between

JPM's stock price and the S&P 500 can also provide insights into the overall risk exposure of a portfolio.

Methodology

To achieve the objectives of this study, we employ various econometric techniques to analyze the stationarity properties and potential long-run relationship between the stock price of JPM and the S&P 500. We begin by testing the stationarity of the two time series using the Augmented Dickey-Fuller (ADF) test. Next, we examine the possibility of cointegration between the two variables using residual-based cointegration tests. As cointegration is found to exist, we estimate the long-run relationship between the variables and construct error correction models (ECMs) to analyze their short-term dynamics.

Data

The data used in this study consists of monthly stock price information for JPMorgan Chase & Co. (JPM) and the S&P 500 index from January 2006 to February 2023. The data was sourced from Yahoo Finance. The initial tests on the data indicated non-stationarity; therefore, we applied appropriate transformations such as differencing to induce stationarity where necessary.

Testing Procedure and Estimation

As was mentioned these series were checked for stationarity and trend stationarity by ADF tests. The results of ADF tests showed that both series were initially nonstationary (Tables **1, 2, 3, 4**).

The cointegration relationship was examined between the two variables and according to the results (Tables 7) the residuals are stationary. As the residuals are stationary, we can conclude that there is cointegration between the two series. This means that the two series share a common stochastic trend, and that deviations from the long-run equilibrium relationship are transitory and will eventually be corrected. In practical terms, this implies that changes in one series will have a long-term effect on the other series. For example, if there is a positive shock to JPM's stock price, we would expect to see a corresponding increase in the S&P 500 index in the long run, and vice versa. This information can be useful for investors and analysts in making informed decisions about investment strategies and risk management.

After the cointegration test ECMs were constructed. In this case all coefficients are significant which means that ECM specification is correct.

Conclusion

For two financial indicators stationarity and trend stationarity were checked by ADF. After that we tested for cointegration between the two variables. According to the cointegration test results ECMs were constructed which were well specified because adjustment coefficients were significant and had proper sign.

References

Table 1. ADF test for the log of the stock price of JPM

```
.   dfuller lgpm

Dickey-Fuller test for unit root                   Number of obs   =       205

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.271            -3.475            -2.883            -2.573
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9295
```

Table 2. ADF test for the log of S&P 500

```
.   dfuller lsp500

Dickey-Fuller test for unit root                   Number of obs   =       205

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)              0.170            -3.475            -2.883            -2.573
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9705
```

Table 3. ADF test for S&P 500

```
.   dfuller lsp500, trend

Dickey-Fuller test for unit root                   Number of obs   =       205

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.146            -4.005            -3.436            -3.136
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.5203
```

Table 4. ADF test for the log of the stock price of JPM

```
.   dfuller lgpm, trend

Dickey-Fuller test for unit root                   Number of obs   =       205

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.329            -4.005            -3.436            -3.136
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.4181
```

Figure 1. Dynamics of the log of the stock price of JPM and S&P 500

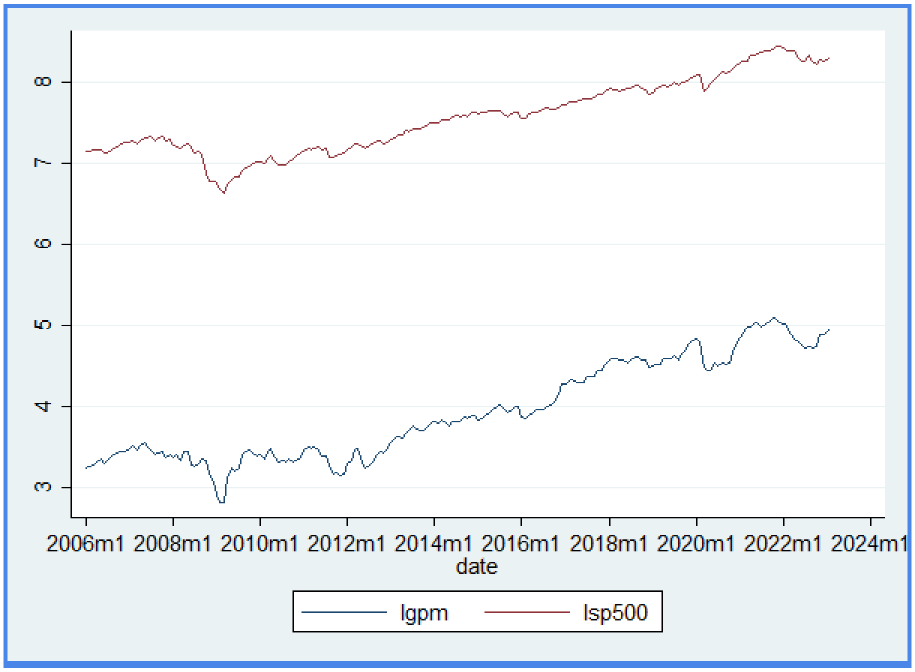

Table 5. Cointegrating relationship without a trend

```
. reg gpm sp500
```

Source	SS	df	MS			
				Number of obs	=	206
				F(1, 204)	=	4664.09
Model	303762.169	1	303762.169	Prob > F	=	0.0000
Residual	13286.0962	204	65.1279227	R-squared	=	0.9581
				Adj R-squared	=	0.9579
Total	317048.265	205	1546.5769	Root MSE	=	8.0702

gpm	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sp500	.0379338	.0005554	68.29	0.000	.0368387	.039029
_cons	-19.45535	1.317777	-14.76	0.000	-22.05356	-16.85714

Figure 2. Dynamics of the residuals

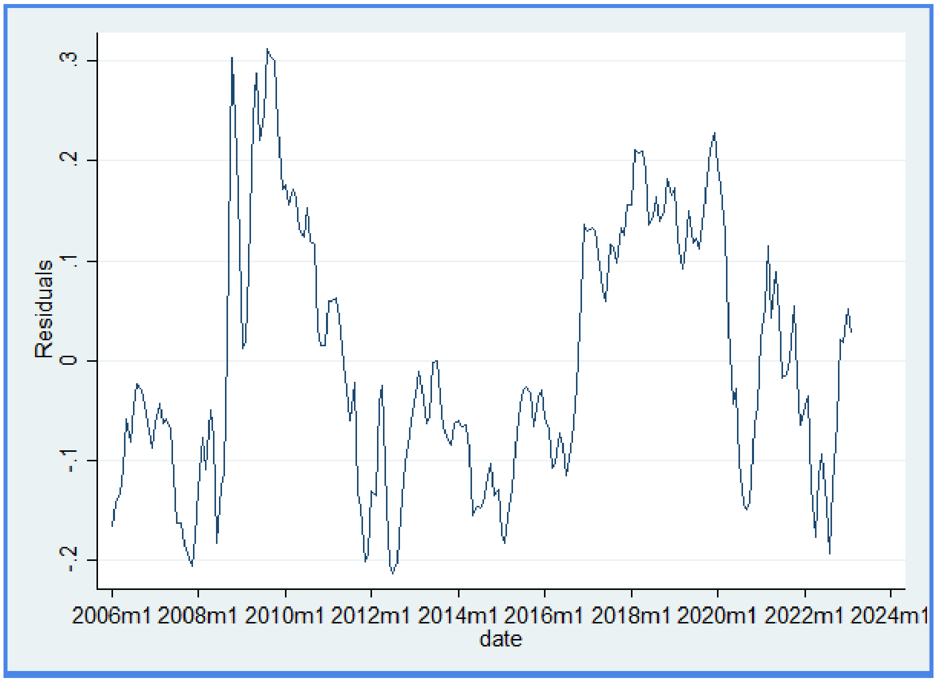

Table 6. Model Order Selection Results

```
.   varsoc ehat , maxlag(8)

   Selection-order criteria
   Sample:  2006m9 - 2023m2                    Number of obs     =      198
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	124.932				.016744	-1.25184	-1.24512	-1.23523
1	323.345	396.83	1	0.000	.00228	-3.24591	-3.23246	-3.21269
2	331.311	15.933*	1	0.000	.002125	-3.31627	-3.29611*	-3.26645*
3	331.869	1.1167	1	0.291	.002134	-3.31181	-3.28492	-3.24538
4	333.221	2.7034	1	0.100	.002127	-3.31536	-3.28175	-3.23233
5	334.323	2.2037	1	0.138	.002124*	-3.31639*	-3.27606	-3.21675
6	334.957	1.2682	1	0.260	.002132	-3.3127	-3.26564	-3.19645
7	335.03	.1457	1	0.703	.002152	-3.30333	-3.24956	-3.17047
8	335.057	.05461	1	0.815	.002174	-3.29351	-3.23301	-3.14404

```
   Endogenous:  ehat
    Exogenous:  _cons
```

Table 7. ADF test for the residuals

```
.   dfuller ehat, noconstant regress lags(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       204

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.597            -2.586            -1.950            -1.617

------------------------------------------------------------------------------
      D.ehat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ehat |
         L1. |  -.0902553   .0250932    -3.60   0.000    -.1397334   -.0407771
         LD. |   .2745754    .067414     4.07   0.000       .14165    .4075007
------------------------------------------------------------------------------
```

Table 8. Short-run ECM

```
.   reg D.L(0/1).lgpm L.ehat D.L(0/1).lsp500

      Source |       SS           df       MS      Number of obs   =       204
-------------+----------------------------------   F(4, 199)       =     55.44
       Model |  .441516359         4  .11037909    Prob > F        =    0.0000
    Residual |  .396199356       199  .001990952   R-squared       =    0.5270
-------------+----------------------------------   Adj R-squared   =    0.5175
       Total |  .837715715       203  .004126678   Root MSE        =    .04462

------------------------------------------------------------------------------
      D.lgpm |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgpm |
         LD. |   .2844349   .0675759     4.21   0.000     .1511782    .4176916
             |
        ehat |
         L1. |  -.0872824    .024835    -3.51   0.001     -.136256   -.0383087
             |
      lsp500 |
         D1. |   1.111773   .0813837    13.66   0.000     .9512881    1.272258
         LD. |   -.210371   .1111186    -1.89   0.060    -.4294922    .0087501
             |
       _cons |   .0008239    .003181     0.26   0.796    -.0054488    .0070966
------------------------------------------------------------------------------
```

Table 9. Breusch-godfrey LM test for autocorrelation

```
.   estat bgodfrey

Breusch-Godfrey LM test for autocorrelation
```

lags(*p*)	chi2	df	Prob > chi2
1	**0.420**	**1**	**0.5167**

H0: no serial correlation