Title : Investigating Influences on Microsoft Stock Price

Objective:

- Identify the key variables that significantly influence Microsoft Stock Price.
- Analyse the dynamic relationships between Microsoft Stock Price and selected macroeconomic and financial variables.

Aim:

Determine which variables play a critical role in influencing Microsoft Stock Price and to interpret their economic and financial significance.

Table of Contents

Data Preparation and Exploration

The data is grouped into three groups based on theoretical relationships Microsoft Stock Price have with each of the components. The data is then transformed into natural logarithm format to minimise any skewness (outlier) present in the data.

Group 1

- S&P Common Stock Price Index : Composite

  The S&P Composite Index reflects overall market performance and investor sentiment. As a major component of the stock market, Microsoft's stock price is expected to have a strong correlation with the S&P index. A rise in the index typically signals positive market conditions, which can boost Microsoft's stock price.

- 10-Year U.S. Treasury Bond Yield

  The 10-year yield is a key indicator of long-term interest rates and reflects expectations of future economic conditions and monetary policy. Higher yields increase the discount rate used to value future cash flows, negatively impacting stock prices, including Microsoft's. Conversely, lower yields can support higher stock valuations.

- Consumer Price Index (CPI)

  The CPI serves as a measure of inflation, which can affect consumer spending, purchasing power, and corporate profitability. Rising inflation could lead to higher interest rates and increased costs, potentially reducing Microsoft's profit margins and stock price.

Group 2

- Industrial Production Index

  The Industrial Production Index measures the output of the manufacturing, mining, and utilities sectors, providing insight into overall economic activity. A strong industrial production environment may indicate robust economic growth, which can benefit companies like Microsoft through increased demand for their technology products and services.

- 5-Year Treasury Rate

  The 5-year Treasury rate reflects medium-term interest rate expectations. It impacts borrowing costs and corporate investment decisions. Rising rates may increase financing costs for Microsoft, reducing profitability, while declining rates can have the opposite effect.

- M1 Money Supply

  M1 Money Supply represents the liquidity available in the economy. Higher liquidity, often

  driven by expansionary monetary policies, tends to encourage investment in equities, including Microsoft stock. Conversely, tighter monetary policies and reduced liquidity can negatively impact stock prices.

Group 3

- Bank of America Merrill Lynch US Corporate Bond Index

  This index reflects credit market conditions for corporations. A strong performance in the corporate bond market indicates favourable financing conditions for companies like Microsoft, potentially lowering their cost of capital and boosting stock prices.

- Consumer Credit or Commercial Credit

  Consumer and commercial credit levels reflect the ability of businesses and individuals to borrow and spend. High credit growth may indicate strong economic activity and increased demand for Microsoft's products and services, positively impacting its stock price.

- 3-Month U.S. Treasury Bill Yield

  The 3-month yield represents short-term interest rate expectations and is influenced by central bank policies. Rising short-term rates can lead to higher borrowing costs and reduced corporate profitability, potentially lowering stock prices. Conversely, falling short-term rates may have a stimulative effect on equities, including Microsoft stock.

Stationarity Test

Augmented Dickey-Fuller (ADF) Test

H0: Series has a unit root

H1: Series does not have unit root

lnmicrosoft:

Null Hypothesis: LNMICROSOFT has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.675756	0.7584
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnmicrosoft has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNMICROSOFT) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.80865	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnmicrosoft does not have a unit root. Thus, lnmicrosoft is stationary at 1st difference.

lnsnp:

Null Hypothesis: LNSNP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.922936	0.6386
Test critical values:	1% level	-4.006566	
	5% level	-3.433401	
	10% level	-3.140550	

At level, we fail to reject null hypothesis, therefore, lnsnp has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNSNP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.97995	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnsnp does not have a unit root. Thus, lnsnp is stationary at 1st difference.

lnustb10y:

Null Hypothesis: LNUSTB10Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.982456	0.1399
Test critical values:	1% level	-4.006566	
	5% level	-3.433401	
	10% level	-3.140550	

At level, we fail to reject null hypothesis, therefore, lnustb10y has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNUSTB10Y) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.95202	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnustb10y does not have a unit root. Thus, lnustb10y is stationary at 1st difference.

lncpi:

Null Hypothesis: LNCPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.118072	0.5320
Test critical values:	1% level	-4.006824	
	5% level	-3.433525	
	10% level	-3.140623	

At level, we fail to reject null hypothesis, therefore, lncpi has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNCPI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.997545	0.0000
Test critical values:	1% level	-3.464643	
	5% level	-2.876515	
	10% level	-2.574831	

At 1st difference, we reject the null hypothesis, therefore, lncpi does not have a unit root. Thus, lncpi is stationary at 1st difference.

lnindpro:

Null Hypothesis: LNINDPRO has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.940819	0.1522
Test critical values:	1% level	-4.007347	
	5% level	-3.433778	
	10% level	-3.140772	

At level, we fail to reject null hypothesis, therefore, lnindpro has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNINDPRO) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.625645	0.0061
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

At 1st difference, we reject the null hypothesis, therefore, lnindpro does not have a unit root. Thus, lnindpro is stationary at 1st difference.

lngs5:

Null Hypothesis: LNGS5 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.799156	0.7016
Test critical values:	1% level	-4.006566	
	5% level	-3.433401	
	10% level	-3.140550	

At level, we fail to reject null hypothesis, therefore, lngs5has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNGS5) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.37489	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lngs5 does not have a unit root. Thus, lngs5 is stationary at 1st difference.

lnm1supply:

Null Hypothesis: LNM1SUPPLY has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.094286	0.5451
Test critical values:	1% level	-4.009558	
	5% level	-3.434844	
	10% level	-3.141399	

At level, we fail to reject null hypothesis, therefore, lnm1supply has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNM1SUPPLY) has a unit root
Exogenous: Constant
Lag Length: 11 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.167950	0.2189
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

At 1st difference, we fail to reject null hypothesis, therefore, lnm1supply has a unit root. We proceed with test at the 2nd difference.

Null Hypothesis: D(LNM1SUPPLY,2) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.394028	0.0000
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

At 2nd difference, we reject the null hypothesis, therefore, lnm1supply does not have a unit root. Thus, lnm1supply is stationary at 2nd difference.

lnbminusa:

Null Hypothesis: LNBMINUSA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.973565	0.1424
Test critical values:	1% level	-4.006566	
	5% level	-3.433401	
	10% level	-3.140550	

At level, we fail to reject null hypothesis, therefore, lnbminusa has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNBMINUSA) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.437304	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnbminusa does not have a unit root. Thus, lnbminusa is stationary at 1st difference.

lnccredit:

Null Hypothesis: LNCCREDIT has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.629951	0.2676
Test critical values:	1% level	-4.009558	
	5% level	-3.434844	
	10% level	-3.141399	

At level, we fail to reject null hypothesis, therefore, lnccredit has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNCCREDIT) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.09834	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnccredit does not have a unit root. Thus, lnccredit is stationary at 1st difference.

lnustb3m:

Null Hypothesis: LNUSTB3M has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.630751	0.9758
Test critical values:	1% level	-4.006824	
	5% level	-3.433525	
	10% level	-3.140623	

At level, we fail to reject null hypothesis, therefore, lnustb3m has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNUSTB3M) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.86849	0.0000
Test critical values:	1% level	-3.464643	
	5% level	-2.876515	
	10% level	-2.574831	

At 1st difference, we reject the null hypothesis, therefore, lnustb3m does not have a unit root. Thus, lnustb3m is stationary at 1st difference.

Phillips-Perron (PP) Test

H0: Series has a unit root

H1: Series does not have unit root

lnmicrosoft:

Null Hypothesis: LNMICROSOFT has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.483898	0.8320
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnmicrosoft has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNMICROSOFT) has a unit root
Exogenous: Constant
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-14.90032	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnmicrosoft does not have a unit root. Thus, lnmicrosoft is stationary at 1st difference.

lnsnp:

Null Hypothesis: LNSNP has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.064521	0.5618
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnsnp has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNSNP) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-12.09946	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnsnp does not have a unit root. Thus, lnsnp is stationary at 1st difference.

lnustb10y:

Null Hypothesis: LNUSTB10Y has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.590459	0.2852
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnustb10y has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNUSTB10Y) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-10.83749	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnustb10y does not have a unit root. Thus, lnustb10y is stationary at 1st difference.

lncpi:

Null Hypothesis: LNCPI has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.168044	0.5042
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lncpi has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNCPI) has a unit root
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.754440	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lncpi does not have a unit root. Thus, lncpi is stationary at 1st difference.

lnindpro:

Null Hypothesis: LNINDPRO has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 9 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.135403	0.5224
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnindpro has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNINDPRO) has a unit root
Exogenous: Constant
Bandwidth: 9 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-12.35456	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnindpro does not have a unit root. Thus, lnindpro is stationary at 1st difference.

lngs5:

Null Hypothesis: LNGS5 has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.528123	0.8167
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lngs5 has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNGS5) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.32473	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lngs5 does not have a unit root. Thus, lngs5 is stationary at 1st difference.

lnm1supply:

Null Hypothesis: LNM1SUPPLY has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.744010	0.7278
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnm1supply has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNM1SUPPLY) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-16.18154	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnm1supply does not have a unit root. Thus, lnm1supply is stationary at 1st difference.

lnbminusa:

Null Hypothesis: LNBMINUSA has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.582945	0.2887
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnbminusa has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNBMINUSA) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.446077	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnbminusa does not have a unit root. Thus, lnbminusa is stationary at 1st difference.

lnccredit:

Null Hypothesis: LNCCREDIT has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.438646	0.8466
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnccredit has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNCCREDIT) has a unit root
Exogenous: Constant
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.02124	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnccredit does not have a unit root. Thus, lnccredit is stationary at 1st difference.

lnustb3m:

Null Hypothesis: LNUSTB3M has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.016954	0.9382
Test critical values:	1% level	-4.006311	
	5% level	-3.433278	
	10% level	-3.140478	

At level, we fail to reject null hypothesis, therefore, lnustb3m has a unit root. We proceed with test at the 1st difference.

Null Hypothesis: D(LNUSTB3M) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

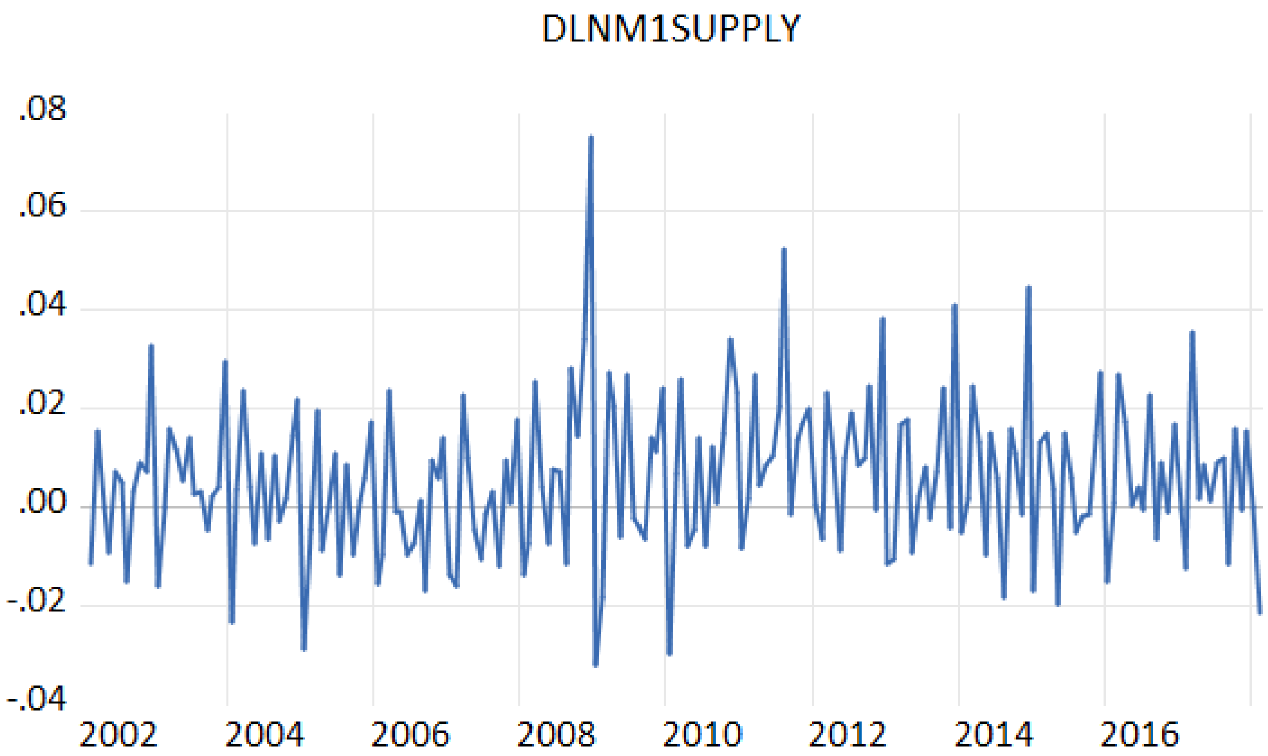
		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-12.17768	0.0000
Test critical values:	1% level	-3.464460	
	5% level	-2.876435	
	10% level	-2.574788	

At 1st difference, we reject the null hypothesis, therefore, lnustb3m does not have a unit root. Thus, lnustb3m is stationary at 1st difference.

Overall Result

Variable	Order of Integration	
	ADF	PP
lnmicrosoft	I(1)	I(1)
lnsnp	I(1)	I(1)
lnustb10y	I(1)	I(1)
lncpi	I(1)	I(1)
lnindpro	I(1)	I(1)
lngs5	I(1)	I(1)
lnm1supply	I(2)	I(1)
lnbminusa	I(1)	I(1)
lnccresidt	I(1)	I(1)
lnustb3m	I(1)	I(1)

The order of integration for all the variables except lnm1supply is I(1). The ADF and PP tests shows conflicting result (different difference level) for lnm1supply. As such, we try to look at the graph of the 1st difference for lnm1supply to determine if we can proceed with it.



The graph shows that the data is mean reverting with the spread remain roughly constant throughout the years. This lines up with the characteristics of stationary data. Therefore, lnm1supply is stationary at 1st difference. Thus, we will proceed order of integration for lnm1supply as I(1) according to PP test.

Group 1

Johansen Cointegration Testing

The test is done to identify if there is long-term equilibrium relationship among non-stationary variables. It also helps in capturing short-run dynamic and avoids spurious results that may arise when modelling non-stationary data directly. If there is cointegrating relationship within the system, we will model the data as Vector Error Correction Model (VECM). However, if there is no said relationship, we will model data as Vector Autoregression (VAR) Model instead. In this section also, we will determine the optimal lag length for the respective model we have chosen.

Trace Statistic

H0: No cointegrating relationship ($r = 0$)

H1: There is cointegrating relationship ($r \geq 1$)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.065159	23.90116	47.85613	0.9446
At most 1	0.033061	11.03180	29.79707	0.9604
At most 2	0.023745	4.610382	15.49471	0.8487
At most 3	0.000107	0.020392	3.841465	0.8864

Since the p-value = 0.9446 (more than 0.05), we fail to reject the null hypothesis. There is no cointegrating relationship within the system.

Maximum Eigenvalue Statistic

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.065159	12.86936	27.58434	0.8920
At most 1	0.033061	6.421420	21.13162	0.9730
At most 2	0.023745	4.589991	14.26460	0.7924
At most 3	0.000107	0.020392	3.841465	0.8864

H0: No cointegrating relationship ($r = 0$)

H1: There is cointegrating relationship ($r \geq 1$)

Since the p-value = 0.8920 (more than 0.05), we fail to reject the null hypothesis. There is no cointegrating relationship within the system.

Model Selection

Since both trace and maximum eigenvalue statistic shows there is no cointegration relationship within the system, we will select VAR model for our analysis on Group 1. Since the data is non-stationary at level, we will difference the related variables before proceeding with lag selection.

Lag Selection for VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1607.603	NA	3.48e-13	-17.33625	-17.26662	-17.30803
1	1651.576	85.56822	2.57e-13	-17.63866	-17.29051*	-17.49756*
2	1676.937	48.25501	2.32e-13*	-17.73986*	-17.11320	-17.48589
3	1681.598	8.666005	2.63e-13	-17.61727	-16.71209	-17.25043
4	1696.093	26.32736*	2.67e-13	-17.60101	-16.41731	-17.12129
5	1700.962	8.630971	3.02e-13	-17.48067	-16.01845	-16.88807
6	1708.516	13.06736	3.32e-13	-17.38936	-15.64863	-16.68389
7	1717.362	14.91896	3.60e-13	-17.31203	-15.29277	-16.49367
8	1725.504	13.37903	3.94e-13	-17.22707	-14.92930	-16.29584

The optimal lag length is 1 (according to SC/BIC and HQ) or 2 (according to AIC) at 5% level. AIC is preferred over BIC/HQ for smaller dataset (<500 samples), in this case which it is (185 samples).Thus, we select lag 2 for our VAR model.

Diagnostic Testing

Serial Autocorrelation (LM Test)

H0: No serial autocorrelation at lag h

H1: There is serial autocorrelation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	15.44661	16	0.4922	0.966653	(16, 535.3)	0.4923
2	19.75439	16	0.2315	1.241182	(16, 535.3)	0.2316
3	11.40068	16	0.7841	0.710790	(16, 535.3)	0.7841
4	17.88602	16	0.3306	1.121846	(16, 535.3)	0.3307
5	17.13921	16	0.3766	1.074260	(16, 535.3)	0.3767
6	9.477440	16	0.8925	0.589833	(16, 535.3)	0.8925
7	16.11020	16	0.4453	1.008801	(16, 535.3)	0.4454
8	18.13234	16	0.3162	1.137555	(16, 535.3)	0.3163
9	16.88627	16	0.3930	1.058158	(16, 535.3)	0.3931
10	25.98086	16	0.0543	1.641860	(16, 535.3)	0.0543
11	9.384420	16	0.8967	0.583994	(16, 535.3)	0.8968
12	15.95177	16	0.4563	0.998733	(16, 535.3)	0.4564

Since the p-value at lag h (1 until 12) is more than 0.05, we fail to reject null hypothesis. Therefore, there is no serial autocorrelation at all lags.

H0: No serial autocorrelation at lags 1 through h

H1: Serial autocorrelation at lags 1 through h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	15.44661	16	0.4922	0.966653	(16, 535.3)	0.4923
2	40.74687	32	0.1381	1.283817	(32, 632.2)	0.1383
3	50.72804	48	0.3665	1.060191	(48, 645.3)	0.3673
4	64.18066	64	0.4701	1.003730	(64, 640.4)	0.4718
5	85.70734	80	0.3109	1.076365	(80, 629.7)	0.3137
6	95.29823	96	0.5010	0.991900	(96, 616.5)	0.5058
7	110.5088	112	0.5221	0.984572	(112, 602.3)	0.5292
8	126.2836	128	0.5263	0.983410	(128, 587.4)	0.5364
9	143.2143	144	0.5028	0.990997	(144, 572.2)	0.5168
10	176.1145	160	0.1816	1.110684	(160, 556.8)	0.1954
11	184.5227	176	0.3147	1.049881	(176, 541.2)	0.3377
12	207.9337	192	0.2046	1.089563	(192, 525.5)	0.2291

When testing for serial correlation across multiple lags (1 to h), all lag is not significant (p-value more than 0.05, we fail to reject null hypothesis). Therefore, no evidence of serial correlation when considering joint effects across lags up to 12.

Heteroscedasticity (White Test)

H0: No heteroskedasticity present in the residuals

H1: Heteroskedasticity present in the residuals

Joint test:

Chi-sq	df	Prob.
636.9259	440	0.0000

Probability = 0.000 (<0.05), we reject the null hypothesis. Therefore, model suffers from heteroscedasticity. However, since we want to only study dynamic relationships between variables rather than time-varying volatility, the VAR model should be sufficient.

Overall Result

Model do not suffer from serial autocorrelation at all lags but do suffer from heteroscedasticity in the residuals. However, the model is not necessarily invalid because our objective is to identify dynamic interactions of variables which makes heteroscedasticity in residuals not a major issue in our VAR model. Therefore, VAR(2) is adequate in achieving our objective.

Model Estimation and Interpretation

	DLNMICRO...	DLNSNP	DLNUSTB10Y	DLNCPI
DLNMICROSOFT(-1)	-0.190800	-0.019433	-0.049020	-0.008618
	(0.09316)	(0.05755)	(0.09223)	(0.00438)
	[-2.04819]	[-0.33768]	[-0.53153]	[-1.96928]
DLNMICROSOFT(-2)	0.020527	-0.002351	0.116636	-0.011206
	(0.09353)	(0.05778)	(0.09259)	(0.00439)
	[0.21948]	[-0.04068]	[1.25968]	[-2.55052]
DLNSNP(-1)	0.347440	0.155143	0.359785	0.027451
	(0.15149)	(0.09358)	(0.14998)	(0.00712)
	[2.29352]	[1.65784]	[2.39896]	[3.85736]
DLNSNP(-2)	-0.092309	-0.053132	0.211446	0.013080
	(0.15809)	(0.09766)	(0.15651)	(0.00743)
	[-0.58390]	[-0.54405]	[1.35098]	[1.76122]
DLNUSTB10Y(-1)	-0.009634	0.007334	0.160753	0.001522
	(0.07327)	(0.04526)	(0.07254)	(0.00344)
	[-0.13148]	[0.16204]	[2.21609]	[0.44214]
DLNUSTB10Y(-2)	-0.027833	0.027660	-0.176362	-0.002164
	(0.07199)	(0.04447)	(0.07127)	(0.00338)
	[-0.38661]	[0.62196]	[-2.47444]	[-0.63975]
DLNCPI(-1)	-0.416829	0.209224	4.337002	0.612186
	(1.48835)	(0.91942)	(1.47349)	(0.06992)
	[-0.28006]	[0.22756]	[2.94336]	[8.75582]
DLNCPI(-2)	2.463815	0.825178	-2.381671	-0.270659
	(1.47971)	(0.91408)	(1.46493)	(0.06951)
	[1.66507]	[0.90274]	[-1.62579]	[-3.89373]
C	0.002050	0.002463	-0.009790	0.001052
	(0.00564)	(0.00348)	(0.00558)	(0.00026)
	[0.36380]	[0.70763]	[-1.75487]	[3.97430]
R-squared	0.051857	0.034848	0.195328	0.388326
Adj. R-squared	0.010180	-0.007577	0.159958	0.361439
Sum sq. resids	0.823182	0.314134	0.806822	0.001817
S.E. equation	0.067253	0.041545	0.066581	0.003159
F-statistic	1.244273	0.821409	5.522399	14.44299
Log likelihood	249.1571	341.1577	251.0741	833.2554
Akaike AIC	-2.514734	-3.478092	-2.534807	-8.630946
Schwarz SC	-2.361485	-3.324843	-2.381559	-8.477698
Mean dependent	0.005940	0.004510	-0.003210	0.001734
S.D. dependent	0.067598	0.041389	0.072645	0.003954

Determinant resid covariance (dof adj.)	2.06E-13
Determinant resid covariance	1.70E-13
Log likelihood	1723.948
Akaike information criterion	-17.67484
Schwarz criterion	-17.06185
Number of coefficients	36

The interpretation of VAR model is mainly placed on direction and magnitude on coefficients rather than strict hypothesis testing which resulted in the lack of p-value in the output. The t-statistics is shown and compared to ±1.96 for a 5% significance level to determine the significance of the variables. VAR coefficients focus on understanding the immediate and delayed effects of its own-lagged values and other variables' lagged values toward the variable. In this case, we will only focus on the effects towards Microsoft's Stock Price. Our estimated equation for Microsoft Stock Price is as follows,

$$Y_{1t} = c_1 + \phi_{11}^{(1)} Y_{1(t-1)} + \phi_{12}^{(1)} Y_{2(t-1)} + \phi_{13}^{(1)} Y_{3(t-1)} + \phi_{14}^{(1)} Y_{4(t-1)} + \phi_{11}^{(2)} Y_{1(t-2)} + \phi_{12}^{(2)} Y_{1(t-2)} + \phi_{13}^{(2)} Y_{3(t-2)} + \phi_{14}^{(2)} Y_{4(t-2)} + \epsilon_{1t}$$

where,

Y_1 = d(lnmicrosoft)

Y_2 = d(lnsnp)

Y_3 = d(lnustb10y)

Y_4 = d(lncpi)

ϵ_{1t} = error term representing shocks or innovations (white noise)

Own-Lag Effects

d(lnmicrosoft)(-1)

Coefficient = -0.190800

t-statistic = |-2.04819| > 1.96, statistically significant at 5% significance level

Interpretation: A 1% increase in Microsoft's stock price in previous period (lag 1) is associated with 0.1908% decrease in Microsoft's stock price in current period.

d(lnmicrosoft)(-2)

Coefficient = 0.020527

t-statistic = |0.21948| < 1.96, not statistically significant at 5% significance level

Cross-Lag Effects

d(lnsnp)(-1)

Coefficient = 0.347440

t-statistic = |2.29352 | > 1.96, statistically significant at 5% significance level

Interpretation: A 1% increase in S&P Common Stock Price Index: Composite in previous period (lag 1) is associated with 0.3474% increase in Microsoft’s stock price in current period.

d(lnsnp)(-2)

Coefficient = -0.092309

t-statistic = |-0.58390 | < 1.96, not statistically significant at 5% significance level

d(lnustb10y)(-1)

Coefficient = -0.009634

t-statistic = |-0.13148 | < 1.96, not statistically significant at 5% significance level

d(lnsnpustb10y)(-2)

Coefficient = -0.027833

t-statistic = |-0.38861 | < 1.96, not statistically significant at 5% significance level

d(lncpi)(-1)

Coefficient = -0.416829

t-statistic = |-0.28006 | < 1.96, not statistically significant at 5% significance level

d(lncpi)(-2)

Coefficient = 2.473815

t-statistic = |1.66507 | < 1.96, not statistically significant at 5% significance level

Overall Result

Microsoft's stock price in current period is statistically significant affected by its own price in previous period (lag 1) and S&P stock price index in previous period (lag 1). However, this interpretation of the VAR model itself is not sufficient in analysing the dynamic relationship in the system especially considering heteroscedasticity in the residuals, therefore, we use Impulse Response Function (IRF) and Variance Decomposition (VD) to help in our analysis.

Causality and Dynamic Analysis

Granger-Causality Test

Dependent variable: DLNMICROSOFT

Excluded	Chi-sq	df	Prob.
DLNSNP	5.568356	2	0.0618
DLNUSTB10Y	0.184624	2	0.9118
DLNCPI	3.130494	2	0.2090
All	9.154246	6	0.1651

S&P Stock Price Index significantly Granger-causes Microsoft Stock Price at the 10% significance level. The 10-year U.S Treasury Bond Yield and Consumer Price Index DO NOT significantly Granger-causes Microsoft Stock Price at the 10% significance level. The joint test suggests that all variables together DO NOT predict Microsoft Stock Price at 10% significance level.

Dependent variable: DLNSNP

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	0.114353	2	0.9444
DLNUSTB10Y	0.450174	2	0.7984
DLNCPI	1.389001	2	0.4993
All	2.612919	6	0.8556

Microsoft Stock Price, 10-year U.S Treasury Bond Yield and Consumer Price Index DO NOT significantly Granger-causes S&P Stock Price Index at the 10% significance level. The joint test suggests that all variables together DO NOT predict S&P Stock Price Index at 10% significance level.

Dependent variable: DLNUSTB10Y

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	2.165413	2	0.3387
DLNSNP	7.662857	2	0.0217
DLNCPI	8.717907	2	0.0128
All	29.14411	6	0.0001

S&P Stock Price Index and Consumer Price Index individually significantly Granger-causes 10-year U.S Treasury Bond Yield at the 5% significance level. Microsoft Stock Price DO NOT significantly Granger-causes 10-year U.S Treasury Bond Yield at the 10% significance level. The joint test suggests that all variables together predict 10-year U.S Treasury Bond Yield at the 1% significance level.

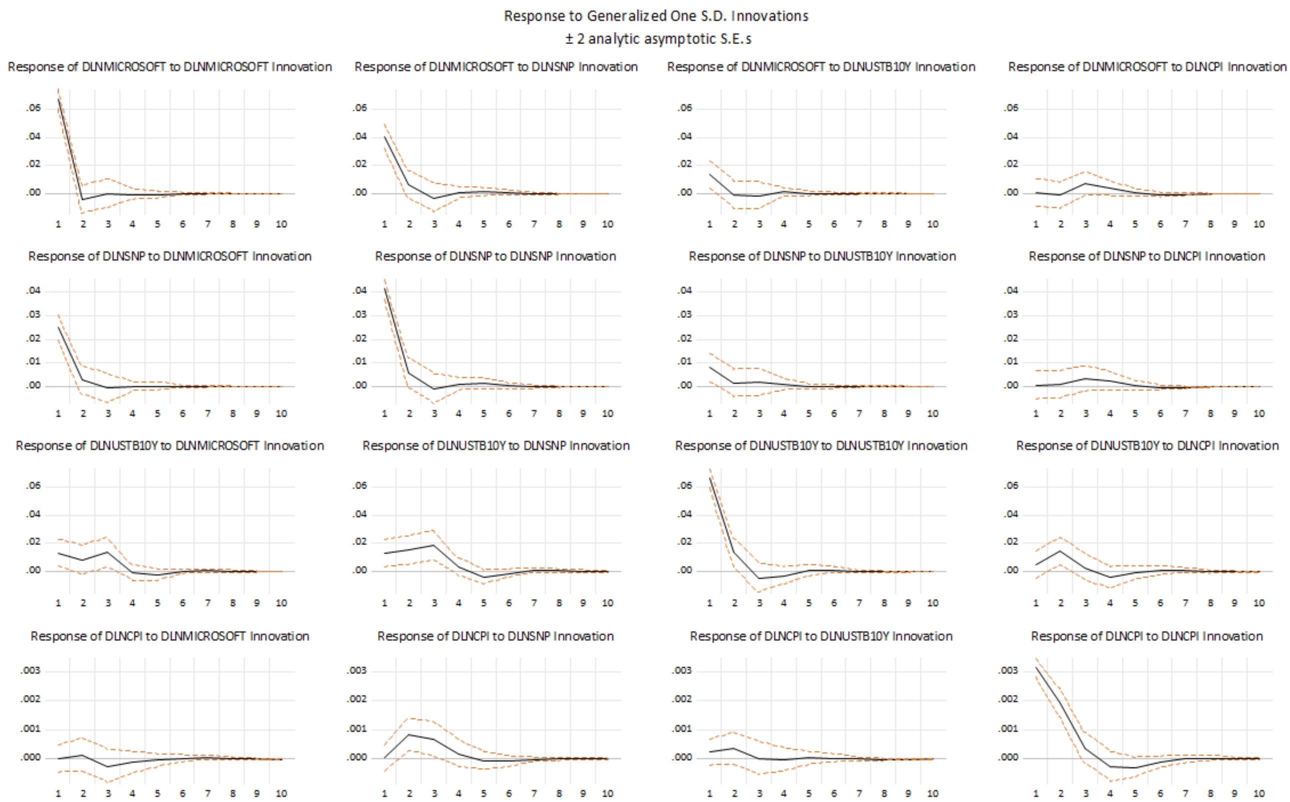
Dependent variable: DLNCPI

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	8.913349	2	0.0116
DLNSNP	18.15480	2	0.0001
DLNUSTB10Y	0.536019	2	0.7649
All	22.18381	6	0.0011

Microsoft Stock Price and S&P Stock Price Index individually significantly Granger-causes Consumer Price Index at the 5% and 1% significance level respectively. 10-year U.S Treasury Bond Yield DO NOT significantly Granger-causes Consumer Price Index at the 10% significance level. The joint test suggests that all variables together predict Consumer Price Index at the 1% significance level.

Impulse Response Function (IRF)

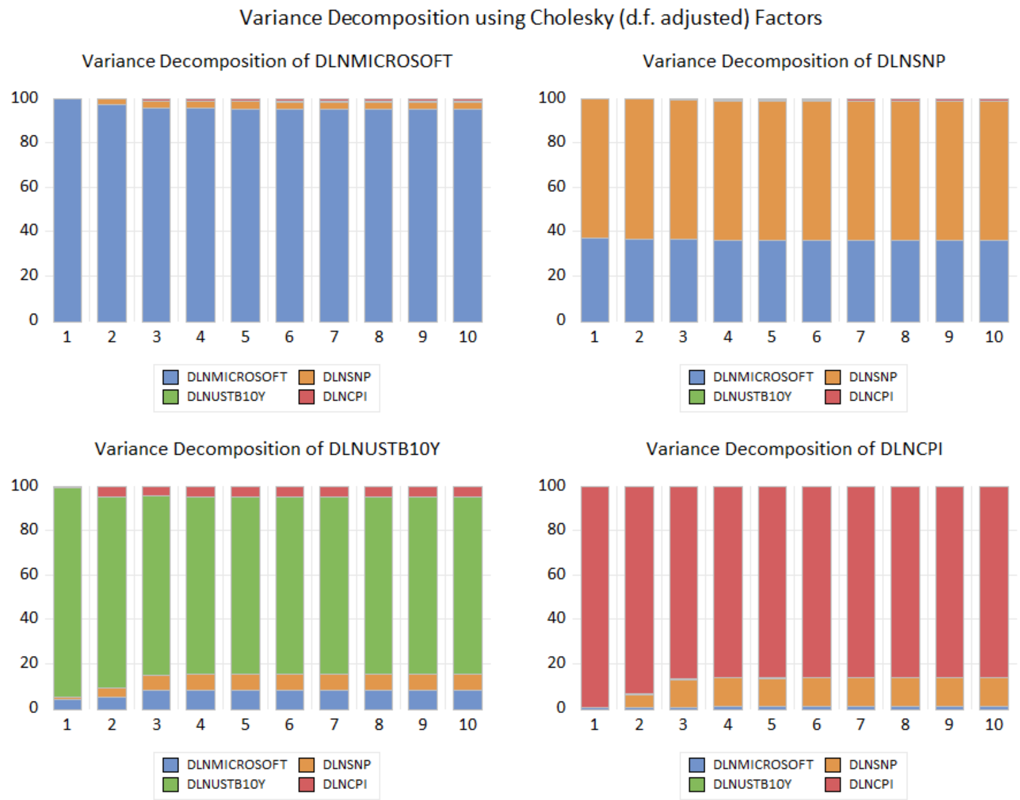
From the Granger-causality test, there are certain contradiction in theory and the result of the test. Based on theory, Microsoft Stock Price is supposedly to affect S&P Stock Price Index as it is a major component of the stock market. Additionally, the 10-year U.S. Treasury Bond Yield and CPI also should affect Microsoft Stock Price (theoretically). Therefore, we choose to use Generalised Impulse Response Function (GIRF) instead of Orthogonalized Impulse Response Function (Cholesky Decomposition). This is mainly because GIRF does not impose strict ordering on variables (order derived from Granger-Causality Test cannot be justified with theory), thus, making GIRF more robust and reliable.



Response of DLNMICROSOFT: Period	DLNMICR...	DLNSNP	DLNUSTB...	DLNCPI
1	0.067253	0.040869	0.013456	0.000372
	(0.00344)	(0.00439)	(0.00482)	(0.00487)
2	-0.004196	0.006496	-0.000525	-0.001252
	(0.00502)	(0.00504)	(0.00484)	(0.00475)
3	0.000328	-0.002987	-0.001372	0.007152
	(0.00498)	(0.00504)	(0.00469)	(0.00408)
4	-0.000480	0.001034	0.001325	0.003927
	(0.00185)	(0.00197)	(0.00147)	(0.00263)
5	-0.000729	0.001205	8.83E-05	0.000966
	(0.00135)	(0.00160)	(0.00087)	(0.00123)
6	-4.85E-05	0.000614	-0.000115	-0.000590
	(0.00051)	(0.00069)	(0.00049)	(0.00081)
7	-0.000102	-0.000104	3.27E-05	-0.000711
	(0.00032)	(0.00048)	(0.00025)	(0.00054)
8	2.84E-05	-0.000229	6.55E-05	-0.000245
	(0.00015)	(0.00025)	(0.00017)	(0.00030)
9	8.66E-05	-5.53E-05	2.05E-05	2.65E-05
	(0.00011)	(0.00013)	(8.9E-05)	(0.00017)
10	4.00E-05	2.59E-05	-1.85E-05	6.93E-05
	(5.8E-05)	(8.1E-05)	(5.2E-05)	(0.00011)

Self-shock in Microsoft Stock Price has the strongest and most immediate impact (period 1), but this effect diminishes quickly. It is followed by the shock from S&P Stock Price Index which has positive short-term effect on Microsoft Stock Price. This lines up with theoretical expectations, as broader market movements often influence individual stock return. Shock from 10-year U.S. Treasury Bond Yield and CPI has negligible effects with responses fluctuating near zero and shows no clear pattern. Overall, the pattern suggests that Microsoft Stock Price is more influenced by its own shocks and by market-wide movements (proxied by S&P), with minimal sensitivity to changes in USTB10Y and CPI.

Variance Decomposition (VD)



Variance Decomposition of DLNMICROSOFT:

Period	S.E.	DLNMICR...	DLNSNP	DLNUSTB...	DLNCPI
1	0.067253	100.0000	0.000000	0.000000	0.000000
2	0.068356	97.17527	2.776536	0.008332	0.039858
3	0.068872	95.72745	3.074500	0.066303	1.131745
4	0.069012	95.34402	3.120535	0.087281	1.448164
5	0.069054	95.24049	3.207165	0.087188	1.465159
6	0.069061	95.21983	3.220221	0.087562	1.472385
7	0.069065	95.20948	3.219922	0.087824	1.482772
8	0.069066	95.20617	3.221822	0.088069	1.483940
9	0.069066	95.20579	3.222192	0.088072	1.483948
10	0.069066	95.20567	3.222187	0.088095	1.484046

Microsoft Stock Price variance is largely self-explanatory, with over 95% of the entire forecast variance explained by its own shock across all periods. S&P Index contribution grows over time, indicating shock from the index start to impact Microsoft Stock Price variance as period increases. There is minimal effect from variance of CPI toward Microsoft Stock Price over period of time and negligible effect from Treasury Bond Yield variance.

Summary

Overall, in this system, financial returns (Microsoft Stock Price and S&P Index) are more interrelated with each other than with macroeconomic indicators (USTB10Y and CPI), which mostly affect their own future values. The interaction between Microsoft and S&P Index are short-lived and macroeconomic variables play a minimal role in influencing these changes. Microsoft Stock Price is self-explanatory in which most of the values can be explained by its own past value. The next biggest influence on Microsoft Stock Price would be the S&P Stock Index.

Insights and Recommendations

Key Variables with their Theoretical and Practical Relevance

- Microsoft Stock Price is self-explanatory in which most of the values can be explained by its own past value. This is consistent with the momentum definition in finance in which financial assets trending strongly in a certain direction will continue to move in that direction. This enables financial analysts and investors to observe historical trends to predict future stock prices and short-term trends.

- S&P Index has a statistically significant and positive effect on Microsoft's Stock Price in the short term. This aligns with the theory that broader market movements, typically represented by the S&P Index, influence individual stock returns especially large-cap companies like Microsoft. For investors, keeping an eye on the broader S&P 500 Index is crucial, as movements in the index, which represents the broader market sentiment, will likely have a significant impact on Microsoft's stock price.

- CPI and USTB10Y show negligible effects on Microsoft Stock Price. Their influence is close to zero. This suggests that macroeconomic indicators, such as inflation and interest rates, have minimal impact on Microsoft's stock price in the short term. Financial analysts may not need to focus heavily on CPI and interest rate movements when forecasting Microsoft’s stock price. While long-term investors should still be aware of macroeconomic trends, short-term volatility in interest rates or inflation is unlikely to affect Microsoft’s stock significantly.

Economic Implication of Result

Self-shock of Microsoft Stock Price:

- Finding is consistent with the Efficient Market Hypothesis (EMH), which suggests that stock prices reflect all available information. Weak form EMH in this case which implies stocks past performance is often a good predictor of its future price as the information is readily available.
- The magnitude of the coefficient for the own-lag effect (-0.1908%) implies that if Microsoft’s stock price increases by 1% in the previous period, it is expected to decrease by about 0.19% in the current period, indicating a short-term mean-reversion tendency in the stock’s behaviour.

S&P Index Positive Impact:

- The positive impact of S&P 500 on Microsoft's stock price aligns with the theory where individual stocks move in the same direction with broader market trends. Given that Microsoft is a major part of the S&P 500 index, this is an expected outcome.
- The coefficient of 0.3474% suggests a relatively moderate sensitivity of Microsoft's stock price to changes in the S&P 500, reinforcing the view that broader market sentiment, especially for large cap firms, plays a role in driving stock returns.

CPI and USTB 10Y's Negligible Impact:

- The negligible impact of CPI and USTB 10Y on Microsoft's stock price suggests that in the short term, macroeconomic indicators like inflation and interest rates have little effect on technology stocks. This finding is consistent with the notion that growth stocks like Microsoft are less sensitive to short-term changes in inflation or interest rates than other sectors such as financial.
- The absence of significant effects from CPI and USTB 10Y reinforces the view that Microsoft's stock is driven more by company-specific factors and broader market trends than by macroeconomic changes in short run.

Recommendations

We recommend that investors monitor Microsoft's stock price and broader market movements, particularly the S&P Index. Investors should focus on tracking the company's earnings, market sentiment, and sector-specific trends, especially within the technology sector. Long-term investors should continue to monitor macroeconomic indicators for potential longer-term risks.

<u>Group 2</u>

Johansen Cointegration Testing

The test is done to identify if there is long-term equilibrium relationship among non-stationary variables. It also helps in capturing short-run dynamic and avoids spurious results that may arise when modelling non-stationary data directly. If there is cointegrating relationship within the system, we will model the data as Vector Error Correction Model (VECM). However, if there is no said relationship, we will model data as Vector Autoregression (VAR) Model instead. In this section also, we will determine the optimal lag length for the respective model we have chosen.

Trace Statistic

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.155983	55.66761	47.85613	0.0078
At most 1	0.081970	23.27734	29.79707	0.2327
At most 2	0.033861	6.941985	15.49471	0.5844
At most 3	0.001896	0.362448	3.841465	0.5471

H0: No cointegrating relationship ($r = 0$)

H1: There is cointegrating relationship ($r \geq 1$)

Since the p-value = 0.0078 (less than 0.05), we reject the null hypothesis. There is cointegrating relationship within the system.

H0: At most one cointegrating relationship ($r \leq 1$)

H1: More than one cointegrating relationship ($r > 1$)

Since p-value is 0.2327 (more than 0.05), we fail to reject null hypothesis. Therefore, there is at most 1 cointegrating relationship.

Maximum Eigenvalue Statistic

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.155983	32.39027	27.58434	0.0111
At most 1	0.081970	16.33536	21.13162	0.2059
At most 2	0.033861	6.579537	14.26460	0.5400
At most 3	0.001896	0.362448	3.841465	0.5471

H0: No cointegrating relationship ($r = 0$)

H1: There is cointegrating relationship ($r \geq 1$)

Since the p-value = 0.0111 (less than 0.05), we reject the null hypothesis. There is cointegrating relationship within the system.

H0: At most one cointegrating relationship ($r \leq 1$)

H1: More than one cointegrating relationship ($r > 1$)

Since p-value is 0.2059 (more than 0.05), we fail to reject null hypothesis. Therefore, there is at most 1 cointegrating relationship

Model Selection

Since both trace and maximum eigenvalue statistic shows there is **ONE** cointegration relationship within the system, we will select VECM for our analysis on Group 2. This implies that the variables lnmicrosoft, lnindpro, lngs5 and lnm1supply share a long-term equilibrium relationship, and deviations from this equilibrium are expected to correct over time. Next, we will proceed with lag selection for our model.

Lag Selection for VECM

Lag	LogL	LR	FPE	AIC	SC	HQ
0	295.7235	NA	4.76e-07	-3.205753	-3.135335	-3.177206
1	1556.265	2451.822	5.47e-13	-16.88203	-16.52994*	-16.73930
2	1580.107	45.32746	5.02e-13	-16.96821	-16.33445	-16.71130
3	1608.798	53.28191	4.37e-13	-17.10767	-16.19224	-16.73656
4	1640.211	56.95799	3.70e-13*	-17.27704*	-16.07994	-16.79175*
5	1655.821	27.61741	3.72e-13	-17.27275	-15.79398	-16.67328
6	1664.415	14.82764	4.05e-13	-17.19137	-15.43093	-16.47772
7	1673.240	14.83699	4.40e-13	-17.11252	-15.07041	-16.28468
8	1683.400	16.63655	4.71e-13	-17.04835	-14.72457	-16.10633
9	1689.852	10.28071	5.27e-13	-16.94343	-14.33798	-15.88722
10	1700.467	16.44704	5.64e-13	-16.88425	-13.99713	-15.71385
11	1723.317	34.40026	5.28e-13	-16.95953	-13.79073	-15.67494
12	1747.803	35.78780*	4.87e-13	-17.05278	-13.60231	-15.65401

The optimal lag length is 1 (according to SC/BIC) or 4 (according to AIC and HQ) at 5% level. AIC is preferred over BIC for smaller dataset (<500 samples), in this case which it is (185 samples). Although longer lag does tend to be overfitting than more parsimonious model (lag 1). However, in our case lag 1 is not feasible (lag interval will become 0 1) which produces a model with no error correction term. Therefore, we choose lag 4 for our model.

Diagnostic Testing

Serial Autocorrelation (LM Test)

H0: No serial autocorrelation at lag h

H1: There is serial autocorrelation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	26.52234	16	0.0471	1.677602	(16, 516.9)	0.0471
2	22.07395	16	0.1408	1.390270	(16, 516.9)	0.1409
3	18.19487	16	0.3126	1.141695	(16, 516.9)	0.3127
4	16.10223	16	0.4458	1.008359	(16, 516.9)	0.4459

Since the p-value at lag 1 is more than 0.01 (1% significance) and p-value at lag 2 until 4 is more than 0.1 (10% significance level), we fail to reject null hypothesis. Therefore, there is no serial autocorrelation at all lags.

H0: No serial autocorrelation at lags 1 through h

H1: Serial autocorrelation at lags 1 through h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	26.52234	16	0.0471	1.677602	(16, 516.9)	0.0471
2	41.84005	32	0.1143	1.319804	(32, 610.1)	0.1145
3	55.16451	48	0.2221	1.157051	(48, 622.2)	0.2229
4	70.35617	64	0.2733	1.105663	(64, 616.9)	0.2750

When testing for serial correlation across multiple lags (1 to h), all lag is not significant (p-value more than 0.01, we fail to reject null hypothesis). Therefore, no evidence of serial correlation when considering joint effects across lags up to 4.

Heteroscedasticity (White Test)

H0: No heteroskedasticity present in the residuals

H1: Heteroskedasticity present in the residuals

Joint test:

Chi-sq	df	Prob.
1141.583	1040	0.0149

Probability = 0.0149 (>0.01), we fail reject the null hypothesis. Therefore, no heteroskedasticity present in the residuals at 1% significance level.

Overall Result

Model do not suffer from serial autocorrelation at all lags and presents homoscedasticity of residuals. Therefore, VECM with lag 3 and 1 cointegration relationship is adequate in achieving our objective.

Model Estimation and Interpretation

Cointegrating Equation

The cointegrating equation represents a long-term equilibrium relationship among non-stationary variables. Our output and estimated equation is as follows.

Cointegrating Eq:	CointEq1
LNMICROSOFT(-1)	1.000000
LNINDPRO(-1)	2.842337 (1.07515) [2.64367]
LNGS5(-1)	-0.074722 (0.12701) [-0.58832]
LNM1SUPPLY(-1)	-1.535494 (0.21708) [-7.07348]
C	-5.233190

$$X_{t-1} = (-2.842337)A_{t-1} + (0.074722)B_{t-1} + (1.535494)C_{t-1} + 5.233190$$

Where,

X= lnmicrosoft

A = lnindpro

B = lngs5

C = lnm1supply

X_{t-1}:

Normalised to 1 in the cointegrating equation. This makes X, lnmicrosoft, as the dependent variable in the long-term equilibrium relationship.

A_{t-1}:

- Coefficient: -2.842337 (negative). If lnindpro increase by 1%, lnmicrosoft will decrease by 2.84 % in the long-term equilibrium. This shows negative elasticity between lnindpro and lnmicrosoft.
- Significance: t-statistic = 2.64367 (|t|>1.96, significant at 5% level). lnindpro has a stable long-term equilibrium relationship with lnmicrosoft in the model as it is statistically significant.

B_{t-1}:

- Coefficient: 0.0747722 (positive). If lngs5 increase by 1%, lnmicrosoft will increase by 0.07% in the long-term equilibrium. This shows positive elasticity between lngs5 and lnmicrosoft.
- Significance: t-statistic = -0.58832 (|t|<1.96, not significant at 5% level). The lack of significance suggests that lngs5 does not have a stable, long-term equilibrium relationship with lnmicrosoft in the model. It may be less relevant in explaining the long-run dynamics of the system.

C_{t-1}:

- Coefficient: 1.535494 (positive). If lnm1supply increase by 1%, lnmicrosoft will increase by 1.54 % in the long-term equilibrium. This shows positive elasticity between lnm1supply and lnmicrosoft.
- Significance: t-statistic = -7.07348 (|t|>1.96, significant at 5% level). lnm1supply has a stable long-term equilibrium relationship with lnmicrosoft in the model as it is statistically significant.

Error Correction Terms

The CointEq1 represents the error correction term which captures the deviation from the long-term equilibrium. It reflects how quickly the model adjusts to long-term equilibrium when there's a deviation. This term is typically negative and significant if there's cointegration between the variables, meaning that short-run deviations from equilibrium will be corrected over time.

Error Correction:	D(LNMICRO...	D(LNINDPRO)	D(LNGS5)	D(LNM1SU...
CointEq1	-0.085404	-0.003167	-0.014871	-0.013369
	(0.01754)	(0.00174)	(0.02907)	(0.00385)
	[-4.86962]	[-1.81925]	[-0.51149]	[-3.47561]

For ΔX (first column):

- Coefficient: -0.085404
- Significance: t-statistic = -4.86962 (|t|>1.96, significant at 5% level).
- About 8.54% of the deviation from the long-term equilibrium is corrected each period, bringing X back towards its equilibrium.

For ΔA (second column):

- Coefficient: -0.0003167
- Significance: t-statistic = -1.81925 (|t|>1.96, significant at 5% level).
- About 0.03% of the deviation from the long-term equilibrium is corrected each period, bringing A back towards its equilibrium.

For ΔB (third column):

- Coefficient: -0.014871
- Significance: t-statistic = -0.51149 ($|t|<1.96$, not significant at 5% level).
- Any deviation of B from long-term equilibrium does not significantly adjust to restore its equilibrium.

For ΔC (third column):

- Coefficient: -0.013369
- Significance: t-statistic = -3.47561 ($|t|>1.96$, significant at 5% level).
- About 1.34% of the deviation from the long-term equilibrium is corrected each period, bringing C back towards its equilibrium.

Short-Run Dynamics

Error Correction:	D(LNMICRO...	D(LNINDPRO)	D(LNGS5)	D(LNM1SU...
CointEq1	-0.085404	-0.003167	-0.014871	-0.013369
	(0.01754)	(0.00174)	(0.02907)	(0.00385)
	[-4.86962]	[-1.81925]	[-0.51149]	[-3.47561]
D(LNMICROSOFT(-1))	-0.091472	-0.000332	0.157107	-0.005223
	(0.07068)	(0.00702)	(0.11717)	(0.01550)
	[-1.29414]	[-0.04727]	[1.34082]	[-0.33690]
D(LNMICROSOFT(-2))	-0.010459	0.007793	0.323066	0.022039
	(0.07089)	(0.00704)	(0.11752)	(0.01555)
	[-0.14754]	[1.10732]	[2.74901]	[1.41744]
D(LNMICROSOFT(-3))	0.054042	0.023922	-0.089779	-0.000342
	(0.07189)	(0.00714)	(0.11918)	(0.01577)
	[0.75172]	[3.35203]	[-0.75332]	[-0.02170]
D(LNINDPRO(-1))	1.009160	0.092022	-1.559554	0.228187
	(0.70567)	(0.07005)	(1.16983)	(0.15477)
	[1.43007]	[1.31363]	[-1.33315]	[1.47435]
D(LNINDPRO(-2))	0.879196	0.158359	-0.870109	-0.093883
	(0.70554)	(0.07004)	(1.16961)	(0.15474)
	[1.24613]	[2.26102]	[-0.74393]	[-0.60671]
D(LNINDPRO(-3))	-0.681665	0.242528	1.661039	-0.550376
	(0.71168)	(0.07065)	(1.17978)	(0.15609)
	[-0.95783]	[3.43292]	[1.40792]	[-3.52607]
D(LNGS5(-1))	-0.003395	0.008409	0.189163	-0.014734
	(0.04671)	(0.00464)	(0.07743)	(0.01024)
	[-0.07268]	[1.81363]	[2.44303]	[-1.43829]
D(LNGS5(-2))	-0.054563	-0.000908	-0.076848	-0.030768
	(0.04615)	(0.00458)	(0.07651)	(0.01012)
	[-1.18225]	[-0.19817]	[-1.00446]	[-3.03972]
D(LNGS5(-3))	-0.035032	0.001655	0.086946	-0.011574
	(0.04573)	(0.00454)	(0.07581)	(0.01003)
	[-0.76605]	[0.36457]	[1.14688]	[-1.15392]
D(LNM1SUPPLY(-1))	-1.158467	-0.048649	-0.401447	-0.305903
	(0.34619)	(0.03437)	(0.57390)	(0.07593)
	[-3.34629]	[-1.41557]	[-0.69950]	[-4.02880]
D(LNM1SUPPLY(-2))	-1.265074	-0.013095	0.566145	-0.352360
	(0.33732)	(0.03349)	(0.55919)	(0.07398)
	[-3.75037]	[-0.39108]	[1.01243]	[-4.76275]
D(LNM1SUPPLY(-3))	-1.388479	-0.077247	0.106356	-0.027165
	(0.34730)	(0.03448)	(0.57574)	(0.07617)
	[-3.99791]	[-2.24057]	[0.18473]	[-0.35663]
C	0.028132	0.001025	-0.005708	0.009797
	(0.00644)	(0.00064)	(0.01068)	(0.00141)
	[4.36616]	[1.60325]	[-0.53434]	[6.93265]

For ΔX (first column, lnmicrosoft)

Lagged ΔX_{t-1} :

- Coefficient: -0.091472
- t-statistic: -1.29414 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔX_{t-1} on current ΔX

Lagged ΔX_{t-2} :

- Coefficient: -0.010459
- t-statistic: - 0.14754 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔX_{t-2} on current ΔX

Lagged ΔX_{t-3} :

- Coefficient: 0.054042
- t-statistic: 0.75172 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔX_{t-3} on current ΔX

Lagged ΔA_{t-1} :

- Coefficient: 1.009160
- t-statistic: 1.43007 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔA_{t-1} on current ΔX

Lagged ΔA_{t-2} :

- Coefficient: 0.879196
- t-statistic: 1.24613 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔA_{t-2} on current ΔX

Lagged ΔA_{t-3} :

- Coefficient: -0.681665
- t-statistic: -0.95783 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔA_{t-3} on current ΔX

Lagged ΔB_{t-1} :

- Coefficient: -0.003395
- t-statistic: -0.07268 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔB_{t-1} on current ΔX

Lagged ΔB_{t-2} :

- Coefficient: -0.054563
- t-statistic: -1.18225 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔB_{t-2} on current ΔX

Lagged ΔB_{t-3} :

- Coefficient: -0.035032
- t-statistic: -0.76605 ($|t|<1.96$, not significant at 5% level)
- Interpretation: No significant short-term impact of ΔB_{t-3} on current ΔX

Lagged ΔC_{t-1} :

- Coefficient: -1.158467
- t-statistic: : -3.34629 ($|t|>1.96$, significant at 5% level)
- Interpretation: Significant short-term impact of ΔC one period ago on current ΔX. A 1% increase in ΔC_{t-1} will decrease ΔX by 1.16% in short term.

Lagged ΔC_{t-2} :

- Coefficient: -1.265074
- t-statistic: : -3.75037 (|t|>1.96, significant at 5% level)
- Interpretation: Significant short-term impact of ΔC two periods ago on current ΔX. A 1% increase in ΔC_{t-1} will decrease ΔX by 1.27% in short term.

Lagged ΔC_{t-2} :

- Coefficient: -1.388479
- t-statistic: : -3.99791 (|t|>1.96, significant at 5% level)
- Interpretation: Significant short-term impact of ΔC one period ago on current ΔX. A 1% increase in ΔC_{t-1} will decrease ΔX by 1.39 % in short term

Summary

- The model captures the long-term equilibrium adjustment for lnindpro and lnm1supply but not for lngs5.

  lnindpro adjusts very slowly toward the long-term equilibrium (0.03%)

  lnm1supply adjusts more quickly toward the long-term equilibrium (1.34%)

- lnm1supply significantly affect lnmicrosoft across all periods, however, other variables show limited short-term interaction with lnmicrosoft.

Causality and Dynamic Analysis

Granger-Causality Test

Dependent variable: D(LNMICROSOFT)

Excluded	Chi-sq	df	Prob.
D(LNINDPRO)	4.507015	3	0.2117
D(LNGS5)	2.337623	3	0.5054
D(LNM1SUPPLY)	25.23263	3	0.0000
All	31.58236	9	0.0002

M1 Money Supply significantly Granger-causes Microsoft Stock Price at the 1% significance level. The Industrial Production Index and 5-year Treasury Rate DO NOT significantly Granger-causes Microsoft Stock Price at the 10% significance level. The joint test suggests that all variables together predict Microsoft Stock Price at 1% significance level mainly driven by M1 Money Supply.

Dependent variable: D(LNINDPRO)

Excluded	Chi-sq	df	Prob.
D(LNMICROSOFT)	11.93617	3	0.0076
D(LNGS5)	3.333929	3	0.3429
D(LNM1SUPPLY)	5.720909	3	0.1260
All	25.71357	9	0.0023

Microsoft Stock Price significantly Granger-causes Industrial Production Index at the 1% significance level. The 5-year Treasury Rate and M1 Money Supply DO NOT significantly Granger-causes The Industrial Production Index at the 10% significance level. The joint test suggests that all variables together predict The Industrial Production Index at 1% significance level mainly driven by Microsoft Stock Price.

Dependent variable: D(LNGS5)

Excluded	Chi-sq	df	Prob.
D(LNMICROSOFT)	9.872539	3	0.0197
D(LNINDPRO)	3.714521	3	0.2940
D(LNM1SUPPLY)	2.189995	3	0.5339
All	18.37622	9	0.0311

Microsoft Stock Price Granger-causes 5-year Treasury Rate at the 5% significance level. The Industrial Production Index and M1 Money Supply DO NOT significantly Granger-causes 5-year Treasury Rate at the 10% significance level. The joint test suggests that all variables together predict 5-year Treasury Rate at the 5% significance level mainly driven by Microsoft Stock Price.

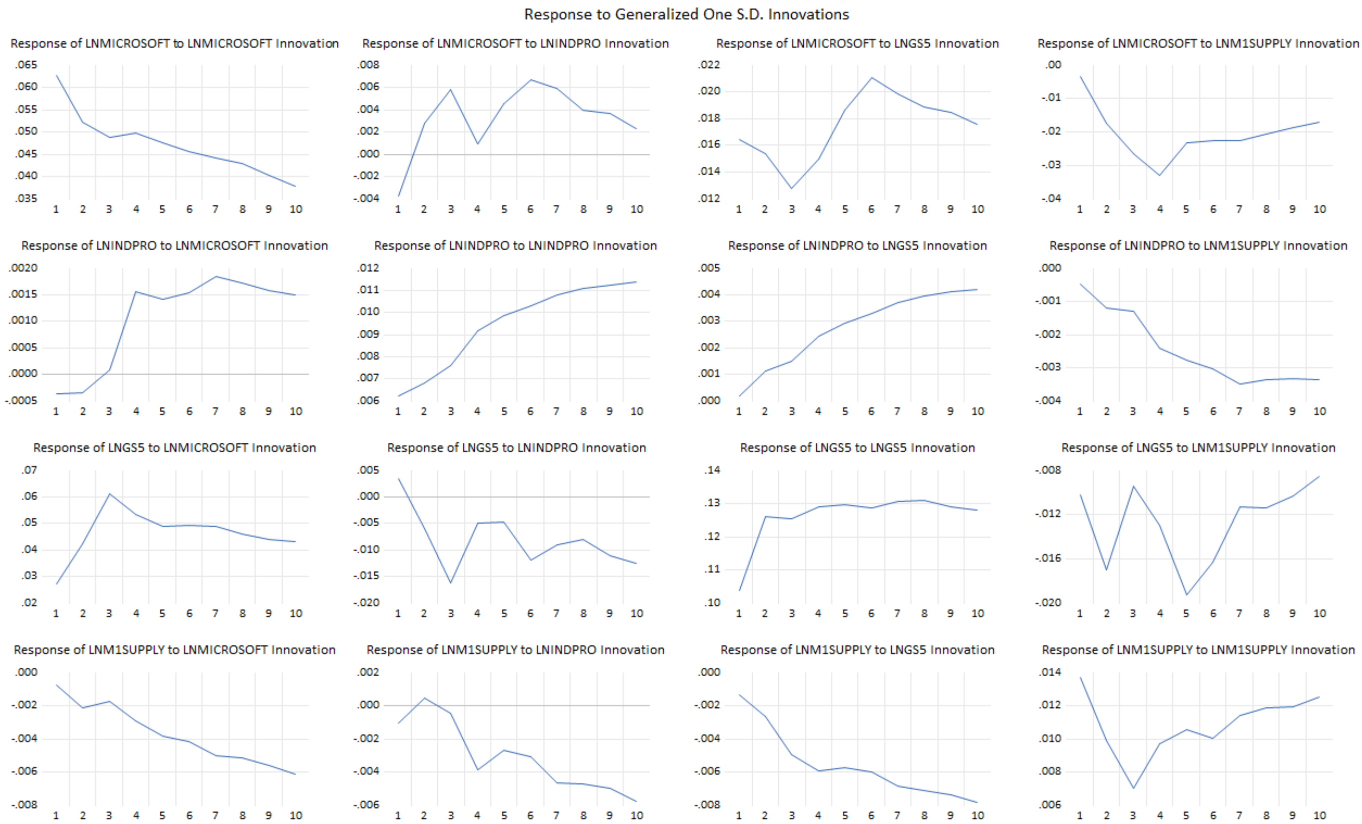
Dependent variable: D(LNM1SUPPLY)

Excluded	Chi-sq	df	Prob.
D(LNMICROSOFT)	2.253916	3	0.5214
D(LNINDPRO)	14.16999	3	0.0027
D(LNGS5)	15.12887	3	0.0017
All	28.23171	9	0.0009

The Industrial Production Index and 5-year Treasury Rate Granger-causes M1 Money Supply at the 1% significance level. Microsoft Stock Price DO NOT significantly Granger-causes M1 Money Supply at the 10% significance level. The joint test suggests that all variables together predict M1 Money Supply at the 1% significance level.

Impulse Response Function (IRF)

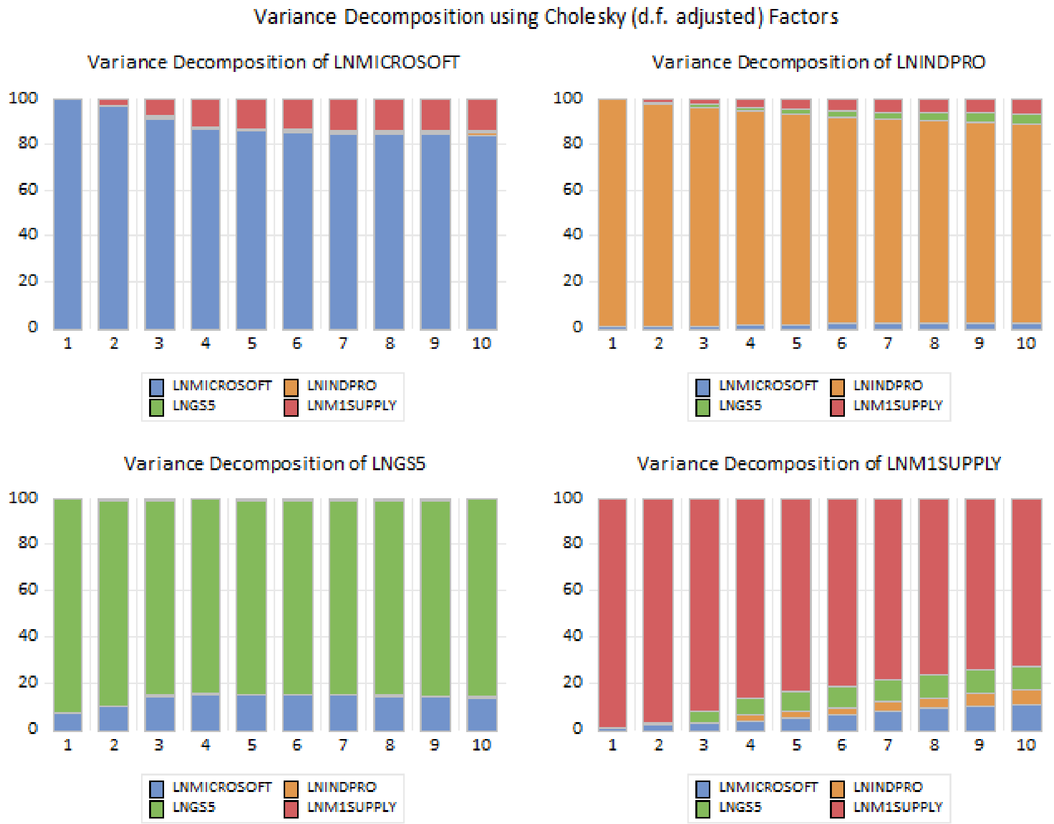
From the Granger-causality test, there are certain contradiction in theory and the result of the test. Based on theory, we expect economic growth (via Industrial Production Index) typically drives stock prices, rather than the reverse. Additionally, economic theory suggests that variables like the Industrial Production Index, M1 Money Supply, and stock prices are likely to interact simultaneously and mutually influence one another, rather than following a strict causal hierarchy. Therefore, we choose to use Generalised Impulse Response Function (GIRF) instead of Orthogonalized Impulse Response Function (Cholesky Decomposition). This is mainly because GIRF does not impose strict ordering on variables (order derived from Granger-Causality Test cannot be justified with theory), thus, making GIRF more robust and reliable.



Response of LNMICROSOFT: Period	LNMICRO...	LNINDPRO	LNGS5	LNM1SUP...
1	0.062595	-0.003770	0.016445	-0.003366
2	0.052076	0.002763	0.015387	-0.017274
3	0.048717	0.005852	0.012768	-0.026534
4	0.049698	0.000937	0.014956	-0.032848
5	0.047573	0.004559	0.018665	-0.023348
6	0.045612	0.006710	0.021054	-0.022440
7	0.044093	0.005949	0.019813	-0.022715
8	0.042845	0.003957	0.018877	-0.020538
9	0.040195	0.003680	0.018453	-0.018632
10	0.037705	0.002328	0.017538	-0.017165

Self-shock in Microsoft Stock Price has the strongest and most immediate impact (period 1), but this effect diminishes over time. Initially, impact from shock of M1 Money Supply is insignificant however, it shows growing negative effect on Microsoft Stock Price as time passes and then decreases. The inverse relationship between the two could stem from investor concerns about inflation, interest rates, and economic instability during the periods (inclusive of Financial Crisis). The 5-year Treasury Rate which has positive persistent but small effect on Microsoft Stock Price. Shock from Industrial Production Index has negligible effects with responses fluctuating near zero and shows no clear pattern. Overall, the pattern suggests that Microsoft Stock Price is more influenced by its own shocks and followed by M1 Money Supply which signify the market conditions and speculations.

Variance Decomposition (VD)



Variance Decomposition of LNMICROSOFT:

Period	S.E.	LNMICRO...	LNINDPRO	LNGS5	LNM1SUP...
1	0.062595	100.0000	0.000000	0.000000	0.000000
2	0.082842	96.60837	0.328917	0.001291	3.061427
3	0.099313	91.28436	0.709272	0.060917	7.945456
4	0.115104	86.59804	0.544820	0.049432	12.80771
5	0.126482	85.86519	0.659263	0.158895	13.31665
6	0.136363	85.06071	0.900921	0.426916	13.61145
7	0.145069	84.39592	1.028303	0.576583	13.99920
8	0.152570	84.18822	1.040796	0.681818	14.08917
9	0.158844	84.07254	1.051154	0.799768	14.07654
10	0.164122	84.02934	1.027265	0.904613	14.03878

Microsoft Stock Price has most of its forecast error variance explained by its own shock initially. However, this self-influence shock decreases over time. M1 Money Supply contribution grows over time, indicating shock from the central bank decision to impact Microsoft Stock Price variance as period increases. There is minimal effect from variance of Industrial Production Index toward Microsoft Stock Price over period of time and negligible effect from 5-year Treasury Rate variance.

Summary

Overall, in this system, Microsoft Stock Price is most influenced by its own past values, with the strongest impact occurring immediately but diminishing over time. The next biggest influence comes from M1 Money Supply, whose impact grows as time progresses, reflecting the role of central bank policies in shaping market conditions. The 5-year Treasury Rate has a small but persistent positive effect on Microsoft's stock, while the Industrial Production Index plays a minimal role in driving Microsoft's stock price movements. This suggests that Microsoft's stock price is primarily driven by its own dynamics, followed by market expectations around monetary policy.

Insights and Recommendations

Key Variables with their Theoretical and Practical Relevance

- Microsoft Stock Price is self-dependent with immediate and strong responses to its own shocks. This aligns with the result we obtained from Group 1 VAR(2) Model in which it follows the EMH.

- Industrial Production Index has a statistically significant and negative effect on Microsoft's Stock Price in the long run. Typically, industrial production is an indicator of overall economic growth. However, the negative relationship in this case suggests that as industrial production rises, investor might shift their focus towards the manufacturing, mining and utilities sectors. This can potentially divert investment away from technology stocks like Microsoft. Investors should be aware that strong industrial growth could indicate a shift in market sentiment, which may affect the tech sector negatively. Therefore, tracking industrial production can help anticipate potential headwinds for Microsoft's stock price.

- GS5 show negligible effects on Microsoft Stock Price. Their influence is close to zero. This suggests that Microsoft stock may not be as responsive to interest rate, represented by government bond yields. We can imply that tech stocks are more driven by growth expectations rather than immediate economic conditions.

- M1 Money Supply has a statistically significant and positive effect on Microsoft's Stock Price in the long run. In economic theory, an increase in the money supply generally boosts liquidity. This can lead to higher stock prices as increased liquidity encourage investment in equities and the availability of more capital in the economy will likely push asset prices higher. Investors should be cautious of monetary policy changes which affects the M1 Money Supply. Any changes made may provide valuable insight into Microsoft Stock Price in the future.

Economic Implication of Result

Microsoft Stock Price:

- Microsoft stock price adjusts rather quickly to deviations from equilibrium (8.54%) in short term.
- Self-dependent nature from findings is consistent with the Efficient Market Hypothesis (EMH), which suggests that stock prices reflect all available information. Weak form EMH in this case which implies stocks past performance is often a good predictor of its future price as the information is readily available.

M1 Money Supply:

- Adjusts very slowly to deviations from equilibrium (0.03%) in short term
- Has a strong positive impact in the long term. This aligns with economic theory, suggesting that an increase in money supply typically leads to higher asset prices due to increased liquidity.
- Short term observation suggests that the market could initially react negatively to a surprise shock to M1 Money Supply because it might not be clear whether the money supply increase is a sign of economic instability or just a routine monetary policy adjustment. This leads to short-term volatility or negative sentiment, which would decrease stock prices in the immediate aftermath (based on IRF result).

Industrial Production Index:

- Adjusts slowly to deviations from equilibrium (1.34 %) in short term
- Negative relationship towards Microsoft stock price in long-run. Potentially counterintuitive but could reflect a shift in investment from technology stocks to more traditional sectors during periods of industrial growth.

5-year Treasury Rate:

- does not significantly affect Microsoft stock in long or short term: This suggests that technology stocks may be less sensitive to interest rate changes compared to other sectors.

Recommendations

Investors should focus on monitoring M1 Money Supply closely, as its changes have a significant impact on Microsoft stock price, particularly during periods of monetary easing. Given that Microsoft stock adjusts quickly to deviations from equilibrium, short-term fluctuations can present opportunities. Additionally, attention should also be given to industrial production trends that could drive reallocation of investments between tech and more cyclical sectors. While interest rates (proxied by the 5-year Treasury rate) have little direct effect, market sentiment and company-specific factors will remain key in driving stock price. Diversifying portfolios with sectors that are more sensitive to interest rates or industrial production may help hedge against risks in the tech sector, especially when economic conditions change.

Group 3

Johansen Cointegration Testing

The test is done to identify if there is long-term equilibrium relationship among non-stationary variables. It also helps in capturing short-run dynamic and avoids spurious results that may arise when modelling non-stationary data directly. If there is cointegrating relationship within the system, we will model the data as Vector Error Correction Model (VECM). However, if there is no said relationship, we will model data as Vector Autoregression (VAR) Model instead. In this section also, we will determine the optimal lag length for the respective model we have chosen.

Trace Statistic

H0: No cointegrating relationship (r = 0)

H1: There is cointegrating relationship (r ≥ 1)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.105624	43.73022	47.85613	0.1157
At most 1	0.088123	22.40913	29.79707	0.2763
At most 2	0.024744	4.789380	15.49471	0.8308
At most 3	2.02E-05	0.003856	3.841465	0.9492

Since the p-value = 0.1157 (more than 0.05), we fail to reject the null hypothesis. There is no cointegrating relationship within the system.

Maximum Eigenvalue Statistic

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.105624	21.32109	27.58434	0.2573
At most 1	0.088123	17.61975	21.13162	0.1447
At most 2	0.024744	4.785524	14.26460	0.7686
At most 3	2.02E-05	0.003856	3.841465	0.9492

H0: No cointegrating relationship ($r = 0$)

H1: There is cointegrating relationship ($r \geq 1$)

Since the p-value = 0.8920 (more than 0.05), we fail to reject the null hypothesis. There is no cointegrating relationship within the system.

Model Selection

Since both trace and maximum eigenvalue statistic shows there is no cointegration relationship within the system, we will select VAR model for our analysis on Group 3. Since the data is non-stationary at level, we will difference the related variables before proceeding with lag selection.

Lag Selection for VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	998.7983	NA	1.98e-10	-10.99225	-10.92156*	-10.96359
1	1035.534	71.44167	1.57e-10	-11.22137	-10.86794	-11.07808*
2	1054.040	35.17268	1.53e-10*	-11.24907*	-10.61290	-10.99115
3	1066.661	23.42819	1.59e-10	-11.21172	-10.29282	-10.83918
4	1081.974	27.74957	1.60e-10	-11.20413	-10.00249	-10.71696
5	1094.683	22.46937	1.67e-10	-11.16777	-9.683386	-10.56597
6	1105.633	18.87516	1.77e-10	-11.11197	-9.344845	-10.39554
7	1116.663	18.52445	1.87e-10	-11.05705	-9.007181	-10.22599
8	1122.945	10.27416	2.10e-10	-10.94967	-8.617065	-10.00398
9	1133.287	16.45557	2.25e-10	-10.88715	-8.271804	-9.826833
10	1149.888	25.68040	2.25e-10	-10.89379	-7.995700	-9.718840
11	1167.774	26.87910	2.23e-10	-10.91463	-7.733805	-9.625056
12	1192.330	35.81705*	2.06e-10	-11.00918	-7.545610	-9.604972

The optimal lag length is 0 (according to SC/BIC), 1 (according to HQ) or 2 (according to AIC) at 5% level. AIC is preferred over BIC/HQ for smaller dataset (<500 samples), in this case which it is (185 samples).Thus, we select lag 2 for our VAR model.

Diagnostic Testing

Serial Autocorrelation (LM Test)

H0: No serial autocorrelation at lag h

H1: There is serial autocorrelation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.60713	16	0.0771	1.553064	(16, 535.3)	0.0771
2	28.65470	16	0.0264	1.815341	(16, 535.3)	0.0264
3	19.89099	16	0.2252	1.249923	(16, 535.3)	0.2252
4	31.02508	16	0.0134	1.969850	(16, 535.3)	0.0134
5	16.86282	16	0.3945	1.056665	(16, 535.3)	0.3946
6	22.88532	16	0.1168	1.442085	(16, 535.3)	0.1169
7	17.84739	16	0.3329	1.119382	(16, 535.3)	0.3330
8	8.601001	16	0.9289	0.534854	(16, 535.3)	0.9289
9	10.96423	16	0.8117	0.683303	(16, 535.3)	0.8117
10	27.36084	16	0.0376	1.731288	(16, 535.3)	0.0377

Since the p-value at lag h (1 until 10) is more than 0.01, we fail to reject null hypothesis. Therefore, there is no serial autocorrelation at all lags.

H0: No serial autocorrelation at lags 1 through h

H1: Serial autocorrelation at lags 1 through h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.60713	16	0.0771	1.553064	(16, 535.3)	0.0771
2	50.74175	32	0.0189	1.611266	(32, 632.2)	0.0189
3	71.17434	48	0.0165	1.510788	(48, 645.3)	0.0167
4	89.66327	64	0.0189	1.429640	(64, 640.4)	0.0191
5	100.2084	80	0.0628	1.272517	(80, 629.7)	0.0639
6	116.9260	96	0.0722	1.237543	(96, 616.5)	0.0741
7	124.4685	112	0.1982	1.121138	(112, 602.3)	0.2037
8	145.7495	128	0.1350	1.152709	(128, 587.4)	0.1413
9	169.0641	144	0.0753	1.194585	(144, 572.2)	0.0812
10	187.4102	160	0.0682	1.192972	(160, 556.8)	0.0756

When testing for serial correlation across multiple lags (1 to h), all lag is not significant (p-value more than 0.01, we fail to reject null hypothesis). Therefore, no evidence of serial correlation when considering joint effects across lags up to 12.

Heteroscedasticity (White Test)

H0: No heteroskedasticity present in the residuals

H1: Heteroskedasticity present in the residuals

Joint test:

Chi-sq	df	Prob.
795.4486	440	0.0000

Probability = 0.000 (<0.05), we reject the null hypothesis. Therefore, model suffers from heteroscedasticity. However, since we want to only study dynamic relationships between variables rather than time-varying volatility, the VAR model should be sufficient.

Overall Result

Model do not suffer from serial autocorrelation at all lags but do suffer from heteroscedasticity in the residuals. However, the model is not necessarily invalid because our objective is to identify dynamic interactions of variables which makes heteroscedasticity in residuals not a major issue in our VAR model. Therefore, VAR(2) is adequate in achieving our objective.

Model Estimation and Interpretation

	DLNMICRO...	DLNBMINUSA	DLNCCREDIT	DLNUSTB3M
DLNMICROSOFT(-1)	-0.058235	-0.082373	0.005333	0.866344
	(0.07215)	(0.08323)	(0.00730)	(0.38813)
	[-0.80711]	[-0.98970]	[0.73065]	[2.23209]
DLNMICROSOFT(-2)	-0.037605	0.066521	0.009285	0.190701
	(0.07283)	(0.08402)	(0.00737)	(0.39179)
	[-0.51632]	[0.79177]	[1.26011]	[0.48674]
DLNBMINUSA(-1)	0.094530	0.476603	0.008259	-0.398975
	(0.06475)	(0.07469)	(0.00655)	(0.34829)
	[1.46002]	[6.38139]	[1.26092]	[-1.14553]
DLNBMINUSA(-2)	-0.262858	-0.040541	-0.004229	-0.143525
	(0.06466)	(0.07459)	(0.00654)	(0.34785)
	[-4.06498]	[-0.54350]	[-0.64652]	[-0.41261]
DLNCCREDIT(-1)	-0.212726	-0.137952	0.226250	-0.817293
	(0.73006)	(0.84214)	(0.07386)	(3.92722)
	[-0.29138]	[-0.16381]	[3.06339]	[-0.20811]
DLNCCREDIT(-2)	0.495588	-0.050385	-0.141656	4.420222
	(0.71408)	(0.82371)	(0.07224)	(3.84124)
	[0.69403]	[-0.06117]	[-1.96094]	[1.15073]
DLNUSTB3M(-1)	0.003523	-0.003649	-0.003376	0.115400
	(0.01334)	(0.01539)	(0.00135)	(0.07176)
	[0.26407]	[-0.23713]	[-2.50129]	[1.60811]
DLNUSTB3M(-2)	0.009230	0.012228	0.000999	-0.274957
	(0.01336)	(0.01542)	(0.00135)	(0.07189)
	[0.69073]	[0.79326]	[0.73884]	[-3.82490]
C	0.004936	-0.000910	0.003324	-0.022527
	(0.00584)	(0.00674)	(0.00059)	(0.03142)
	[0.84498]	[-0.13505]	[5.62392]	[-0.71686]
R-squared	0.099048	0.223871	0.114430	0.128727
Adj. R-squared	0.059446	0.189756	0.075504	0.090429
Sum sq. resids	0.782210	1.040830	0.008005	22.63483
S.E. equation	0.065558	0.075623	0.006632	0.352657
F-statistic	2.501065	6.562155	2.939669	3.361210
Log likelihood	254.0327	226.7531	691.6160	-67.33641
Akaike AIC	-2.565787	-2.280138	-7.147811	0.799334
Schwarz SC	-2.412539	-2.126889	-6.994563	0.952583
Mean dependent	0.005940	-0.003316	0.003712	-0.000736
S.D. dependent	0.067598	0.084013	0.006898	0.369772

Determinant resid covariance (dof adj.)	1.26E-10
Determinant resid covariance	1.04E-10
Log likelihood	1110.990
Akaike information criterion	-11.25644
Schwarz criterion	-10.64345
Number of coefficients	36

The interpretation of VAR model is mainly placed on direction and magnitude on coefficients rather than strict hypothesis testing which resulted in the lack of p-value in the output. The t-statistics is shown and compared to ±1.96 for a 5% significance level to determine the significance of the variables. VAR coefficients focus on understanding the immediate and delayed effects of its own-lagged values and other variables' lagged values toward the variable. In this case, we will only focus on the effects towards Microsoft's Stock Price. Our estimated equation for Microsoft Stock Price is as follows,

$$Y_{1t} = c_1 + \phi_{11}^{(1)} Y_{1(t-1)} + \phi_{12}^{(1)} Y_{2(t-1)} + \phi_{13}^{(1)} Y_{3(t-1)} + \phi_{14}^{(1)} Y_{4(t-1)} + \phi_{11}^{(2)} Y_{1(t-2)} + \phi_{12}^{(2)} Y_{1(t-2)} + \phi_{13}^{(2)} Y_{3(t-2)} + \phi_{14}^{(2)} Y_{4(t-2)} + \epsilon_{1t}$$

where,

Y_1 = d(lnmicrosoft)

Y_2 = d(lnbminusa)

Y_3 = d(lnccredit)

Y_4 = d(ustb3m)

ϵ_{1t} = error term representing shocks or innovations (white noise)

Own-Lag Effects

d(lnmicrosoft)(-1)

Coefficient = -0.058235

t-statistic = |-0.80711| < 1.96, not statistically significant at 5% significance level

d(lnmicrosoft)(-2)

Coefficient = -0.037605

t-statistic = |-0.51632 | < 1.96, not statistically significant at 5% significance level

Cross-Lag Effects

d(lnbminusa)(-1)

Coefficient = 0.094530

t-statistic = |1.46002 | < 1.96, not statistically significant at 5% significance level

d(lnbminusa)(-2)
Coefficient = -0.262858
t-statistic = |2.-4.06498 | > 1.96, statistically significant at 5% significance level
Interpretation: A 1% increase in US Corporate Bond Index in previous period (lag 2) is associated with 0.2629% decrease in Microsoft's stock price in current period.

d(lnccredit)(-1)
Coefficient = -0.212726
t-statistic = |-0.29138 | < 1.96, not statistically significant at 5% significance level

d(lnccredit)(-2)
Coefficient = 0.495588
t-statistic = |0.69403 | < 1.96, not statistically significant at 5% significance level

d(lnustb3m)(-1)
Coefficient = 0.003523
t-statistic = |0.26407 | < 1.96, not statistically significant at 5% significance level

d(lnustb3m)(-2)
Coefficient = 0.009230
t-statistic = |0.69073 | < 1.96, not statistically significant at 5% significance level

Overall Result
Microsoft's stock price in current period is statistically significant affected U.S. Corporate Bond Index in previous period (lag 2). However, this interpretation of the VAR model itself is not sufficient in analysing the dynamic relationship in the system especially considering heteroscedasticity in the residuals, therefore, we use Impulse Response Function (IRF) and Variance Decomposition (VD) to help in our analysis.

Causality and Dynamic Analysis

Granger-Causality Test

Dependent variable: DLNMICROSOFT

Excluded	Chi-sq	df	Prob.
DLNBMINUSA	16.63994	2	0.0002
DLNCCREDIT	0.505488	2	0.7767
DLNUSTB3M	0.581928	2	0.7475
All	19.16668	6	0.0039

U.S. Corporate Bond Index significantly Granger-causes Microsoft Stock Price at the 1% significance level. The Consumer or Commercial Credit and 3-month U.S. Treasury Bill Yield DO NOT significantly Granger-causes Microsoft Stock Price at the 10% significance level. The joint test suggests that all variables together predict Microsoft Stock Price at 1% significance level mainly driven by U.S. Corporate Bond Index.

Dependent variable: DLNBMINUSA

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	1.770268	2	0.4127
DLNCCREDIT	0.036099	2	0.9821
DLNUSTB3M	0.658336	2	0.7195
All	2.528377	6	0.8653

Microsoft Stock Price, Consumer or Commercial Credit and 3-month U.S. Treasury Bill Yield DO NOT significantly Granger-causes U.S. Corporate Bond Index at the 10% significance level. The joint test suggests that all variables together DO NOT predict U.S. Corporate Bond Index at 10% significance level.

Dependent variable: DLNCCREDIT

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	1.965314	2	0.3743
DLNBMINUSA	1.601896	2	0.4489
DLNUSTB3M	6.536089	2	0.0381
All	9.647913	6	0.1403

3-month U.S. Treasury Bill significantly Granger-causes Consumer or Commercial Credit at the 5% significance level. U.S. Corporate Bond Index and Microsoft Stock Price DO NOT significantly Granger-causes Consumer or Commercial Credit at the 10% significance level. The joint test suggests that all variables together DO NOT predict Consumer or Commercial Credit at the 10% significance level.

Microsoft Stock Price, U.S. Corporate Bond Index, Consumer or Commercial Credit, 3-month U.S. Treasury Bill Yield

Dependent variable: DLNUSTB3M

Excluded	Chi-sq	df	Prob.
DLNMICROSOFT	5.058989	2	0.0797
DLNBMINUSA	2.334182	2	0.3113
DLNCCREDIT	1.324799	2	0.5156
All	9.622584	6	0.1415

Microsoft Stock Price significantly Granger-causes 3-month U.S. Treasury Bill Yield at the 10% significance level. The U.S. Corporate Bond Index and Consumer or Commercial Credit DO NOT significantly Granger-causes 3-month U.S. Treasury Bill Yield at the 10% significance level. The joint test suggests that all variables together DO NOT predict 3-month U.S. Treasury Bill Yield at the 10% significance level.

Impulse Response Function (IRF)

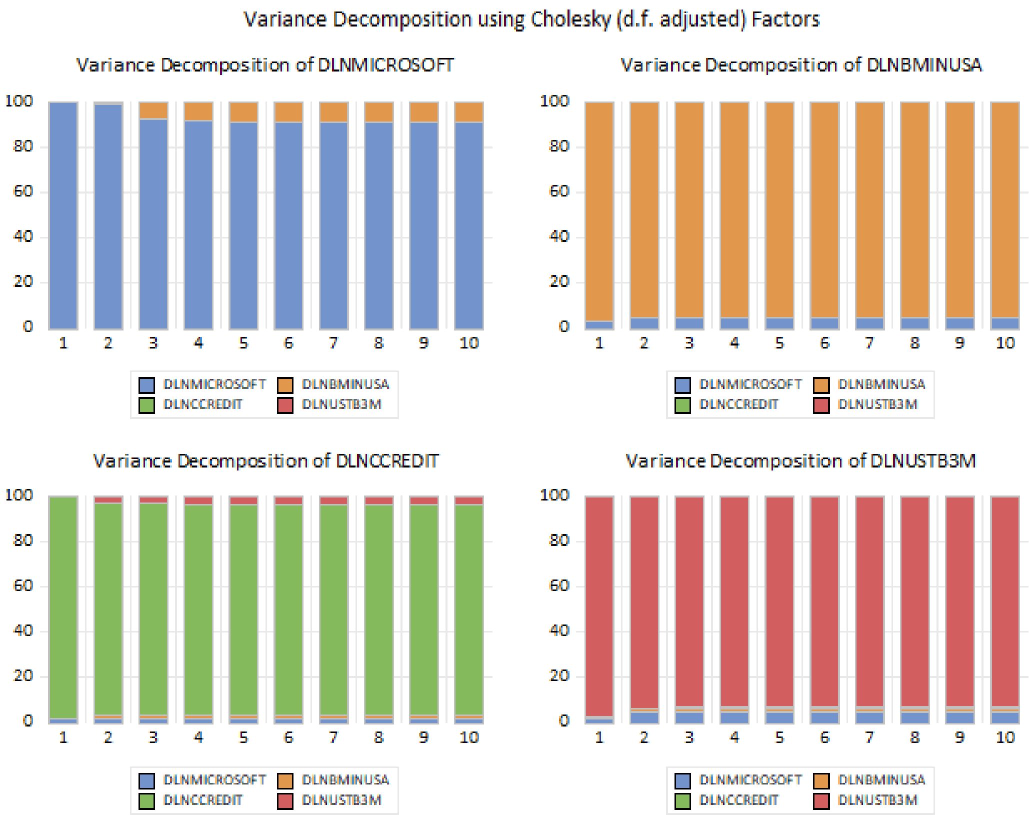
`From the Granger-causality test, there are certain contradiction in theory and the result of the test. Therefore, we choose to use Generalised Impulse Response Function (GIRF) instead of Orthogonalized Impulse Response Function (Cholesky Decomposition). This is mainly because GIRF does not impose strict ordering on variables (order derived from Granger-Causality Test cannot be justified with theory), thus, making GIRF more robust and reliable.

Response of DLNMICROSOFT:

Period	DLNMICR...	DLNBMINU...	DLNCCRE...	DLNUSTB3I
1	0.065558	-0.011150	0.007190	0.006398
	(0.00335)	(0.00471)	(0.00473)	(0.00473)
2	-0.005067	0.007673	-0.001867	0.000260
	(0.00467)	(0.00485)	(0.00483)	(0.00470)
3	0.000945	-0.016999	0.002404	0.004686
	(0.00484)	(0.00448)	(0.00480)	(0.00476)
4	0.003943	-0.007993	0.001212	0.000838
	(0.00204)	(0.00273)	(0.00184)	(0.00213)
5	9.19E-05	-0.001794	0.000154	-0.001726
	(0.00156)	(0.00189)	(0.00146)	(0.00182)
6	-0.000417	-0.001154	4.05E-05	-0.000369
	(0.00081)	(0.00129)	(0.00092)	(0.00102)
7	-4.85E-06	-0.000499	-0.000140	0.000397
	(0.00035)	(0.00071)	(0.00032)	(0.00050)
8	3.78E-05	-5.18E-05	-9.55E-05	9.72E-05
	(0.00022)	(0.00045)	(0.00016)	(0.00025)
9	-2.28E-05	2.91E-05	2.30E-05	-0.000112
	(8.8E-05)	(0.00022)	(7.0E-05)	(0.00016)
10	-2.93E-05	1.99E-05	2.78E-05	-5.04E-05
	(4.1E-05)	(0.00011)	(4.9E-05)	(8.1E-05)

Self-shock in Microsoft Stock Price has the strongest and most immediate impact (period 1), but this effect diminishes quickly. It is followed by the shock from U.S. Corporate Bond Index which has negative short-term effect on Microsoft Stock Price. Shock from Consumer or Commercial Credit and 3-month U.S. Treasury Bill Yield has negligible effects with responses fluctuating near zero and shows no clear pattern. Overall, the pattern suggests that Microsoft Stock Price is more influenced by its own shocks and followed by shocks from U.S. Corporate Bond Index, with minimal sensitivity to changes in credit level and short-term interest rate.

Variance Decomposition (VD)



Variance Decomposition of DLNMICROSOFT:

Period	S.E.	DLNMICR...	DLNBMINU...	DLNCCRE...	DLNUSTB3M
1	0.065558	100.0000	0.000000	0.000000	0.000000
2	0.066144	98.82332	1.092090	0.044747	0.039842
3	0.068461	92.26534	7.248900	0.223672	0.262084
4	0.068983	91.20213	8.300066	0.239227	0.258578
5	0.069033	91.07099	8.356482	0.238980	0.333550
6	0.069046	91.03811	8.385517	0.239049	0.337330
7	0.069049	91.03051	8.390208	0.239266	0.340015
8	0.069049	91.03015	8.390216	0.239449	0.340186
9	0.069050	91.02991	8.390206	0.239455	0.340433
10	0.069050	91.02985	8.390204	0.239472	0.340478

Microsoft Stock Price variance is largely self-explanatory, with over 90% of the entire forecast variance explained by its own shock across all periods. Corporate Bond Index contribution grows over time, indicating shock from the index start to impact Microsoft Stock Price variance as period increases. There is minimal effect from variance of Consumer or Commercial Credit and 3-month U.S. Treasury Bill Yield toward Microsoft Stock Price over period of time.

Summary

Overall, in this system, financial returns (Microsoft Stock Price and Corporate Bond Index) are more interrelated with each other than with macroeconomic indicators (Consumer or Commercial Credit and Treasury Bill Yield), which mostly affect their own future values. The interaction between Microsoft and Corporate Bond Index are short-lived and macroeconomic variables play a minimal role in influencing these changes. Microsoft Stock Price is self-explanatory in which most of the values can be explained by its own past value. The next biggest influence on Microsoft Stock Price would be the U.S. Corporate Bond Index.

Insights and Recommendations

Key Variables with their Theoretical and Practical Relevance

- Microsoft Stock Price is self-explanatory in which most of the values can be explained by its own past value. This is consistent with the momentum definition in finance in which financial assets trending strongly in a certain direction will continue to move in that direction. This enables financial analysts and investors to observe historical trends to predict future stock prices and short-term trends.

- U.S. Corporate Bond Index shows significant influence on Microsoft's stock price. In theory, an inverse relationship between corporate bonds and stocks is plausible. When the bond market is performing well, investors may favour bonds over equities (especially during financial crisis), leading to a decrease in stock prices. The finding that this relationship is statistically significant at lag 2 is interesting as it highlights a delayed reaction of Microsoft's stock price to changes in the bond market. For investors, keeping an eye on change in bond market is important as Microsoft's stock price is sensitive to the changes.

- Consumer or Commercial Credit and 3-Month U.S. Treasury Bill Yield show no statistically significant relationship with Microsoft's stock price, both in terms of their own lagged effects and cross-lagged effects. The insignificance of these variables in affecting Microsoft's stock price suggests that, in the short term, these macroeconomic factors may not have a direct impact on the stock.

Economic Implication of Result

Self-shock of Microsoft Stock Price:

- Microsoft's stock price exhibits some level of autocorrelation. While the effect is not statistically significant in this case, it aligns with financial theories suggesting that stocks tend to follow momentum or revert to the mean over time.
- Finding is consistent with the Efficient Market Hypothesis (EMH), which suggests that stock prices reflect all available information. Weak form EMH in this case which implies stocks past performance is often a good predictor of its future price as the information is readily available.

U.S. Corporate Bond Index:

- A 1% increase in the U.S. Corporate Bond Index (in lag 2) results in a 0.2629% decrease in Microsoft's stock price in the current period. This result suggests an inverse relationship between the corporate bond market and Microsoft's stock price, particularly after two periods.

CCREDIT and USTB3M Negligible Impact:

- The negligible impact of CCREDIT and USTB3M on Microsoft's stock price suggests that in the short term, macroeconomic indicators like credit level and interest rates have little effect on technology stocks. This finding is consistent with the notion that growth stocks like Microsoft are less sensitive to short-term changes in purchasing power or short-term interest rates.
- The absence of significant effects from CCREDIT and USTB3M reinforces the view that Microsoft's stock is driven more by company-specific factors and broader market trends than by macroeconomic changes in short run.

Recommendations

We recommend that investors should closely monitor the U.S. Corporate Bond Index, as it significantly influences Microsoft's stock price with a delayed effect to anticipate future stock price movement. While consumer credit and U.S. Treasury Bill yields show minimal impact, investors should factor in the broader bond market and its movements when forecasting Microsoft's performance. It is also crucial to consider Microsoft's own historical price trends, as past values exert some influence on future price movements. As a risk management strategy, incorporating corporate bond indicators and observing short-term and medium-term market trends will help anticipate potential stock price fluctuations, providing a more comprehensive view for decision-making.