JAPAN MACROECONOMIC OUTLOOK

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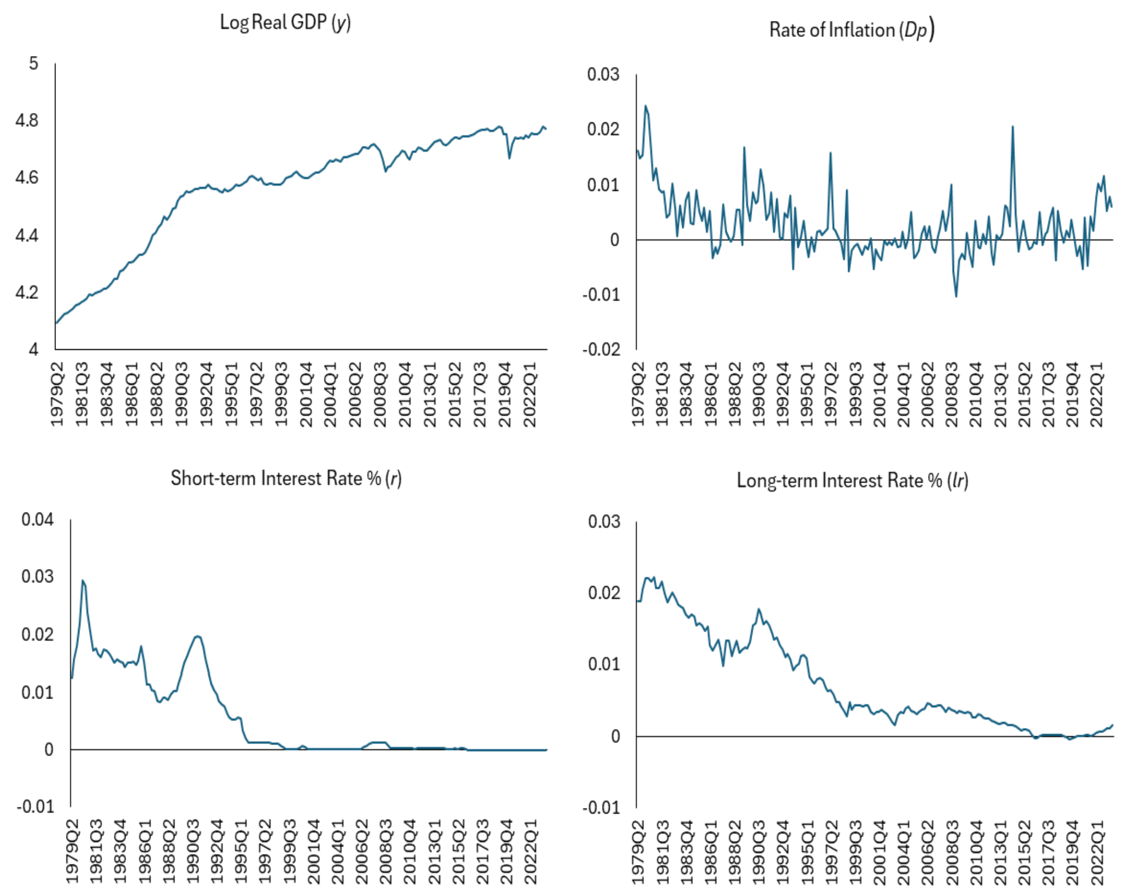
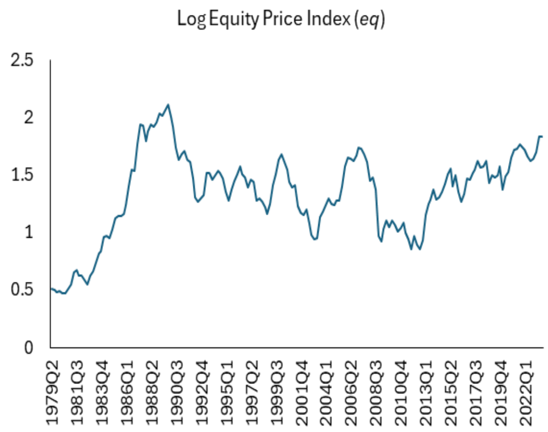
INTRODUCTION

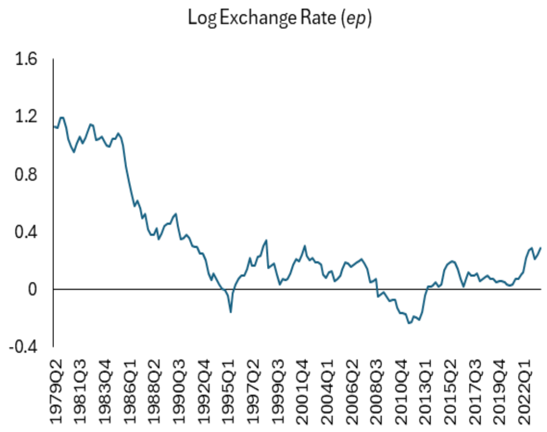
Our paper implements a multivariate time series analysis of Japan's macroeconomy using Vector Autoregression with exogenous variables (VAR-X) to characterize dynamic interdependencies among key macroeconomic indicators and generate out-of-sample forecasts. Japan presents a particularly interesting case study given its distinctive macroeconomic environment characterized by persistent deflationary pressures historically, unconventional monetary policy implementation, and significant exposure to external shocks as a major trading economy (Bernanke, 2000; Ito & Mishkin, 2006).

Our analysis employs quarterly data spanning 1979Q2 to 2022Q3 from the Global Vector Autoregression (GVAR) database (Mohaddes & Raissi, 2020) to estimate a VAR-X model for Japan incorporating six endogenous macroeconomic variables: real GDP (*y*), inflation rate (*Dp*), short-term interest rate (*r*), long-term interest rate (*lr*), real effective exchange rate (*ep*), and equity prices (*eq*). We also include metal prices (*pmetal*) as an endogenous variable, reflecting Japan's position as the world's third-largest steel producer and the importance of this sector to its industrial base. As exogenous variables, we incorporate global oil prices (*poil*) and country-specific foreign variables (the "star variables": *ys*, *Dps*, *rs*, *lrs*, *eqs* constructed as weighted averages of corresponding variables across Japan's major trading partners. This specification captures both Japan's manufacturing-oriented economy's sensitivity to energy price fluctuations (Jiménez-Rodríguez & Sánchez, 2005) and the high degree of integration with global supply chains and international financial markets (Hoshi & Kashyap, 2018).

Japan's Macroeconomic State of Affairs and Outlook







Source: Team Computation from GVAR Dataset

Analysis of Japan's key macroeconomic indicators from 1979 to 2022 reveals several significant trends that shape our outlook for the Japanese economy:

Real GDP: Japan's real GDP shows steady long-term growth with notable disruptions during the 2008 global financial crisis and the 2020 pandemic. The recent trajectory indicates modest recovery from the pandemic-induced contraction, though growth remains vulnerable to external shocks.

Inflation: Inflation has been historically volatile but predominantly low, with frequent periods of deflation—a persistent challenge for Japanese monetary policy. Recent data shows a shift toward positive inflation, likely driven by global supply chain disruptions, energy price increases, and yen depreciation.

Interest Rate: The interest rate environment reflects Japan's prolonged accommodative monetary policy. Short-term rates have remained near zero since the early 2000s, while long-term rates have steadily declined over four decades to near-zero levels. The recent slight uptick in long-term rates suggests potential normalization pressures as global rates rise.

Equity Prices: Equity markets have experienced significant volatility, with the dramatic bubble and crash of the late 1980s/early 1990s still evident. The positive trend since 2012 reflects the impact of "Abenomics" policies, though with considerable fluctuations.

Exchange Rate: The exchange rate shows substantial long-term yen depreciation from its peak in the mid-1990s, with recent data indicating renewed depreciation pressure, likely due to widening interest rate differentials with the United States.

Outlook (2022Q4-2023Q3)

Based on these patterns and recent trends, Japan's economy is expected to experience:

1. Modest GDP growth, constrained by demographic headwinds and global economic uncertainty
2. Continued inflationary pressures, though likely below global averages
3. Potential monetary policy adjustments as the Bank of Japan faces pressure to normalize while managing debt sustainability concerns
4. Ongoing yen weakness if interest rate differentials with major economies persist
5. Equity market performance closely tied to export sector prospects and global risk sentiment.

EMPIRICAL LITERATURE REVIEW

Using a New Keynesian model with a simultaneous equation approach that includes energy prices in the aggregate supply-aggregate demand framework, Yoshino et al. (2017), demonstrated that Japan's monetary policy was ineffective due to a vertical IS curve—where investment doesn't respond to interest rate changes despite the Bank of Japan's quantitative easing efforts. Their empirical analysis of Japanese data shows that while oil price increases significantly affected inflation rates, monetary stimulus failed to stimulate economic growth because of structural issues including an aging population and low marginal productivity of capital. The authors argue that the BOJ's 2% inflation target was unrealistic in an era of declining oil prices, as cheaper oil shifts the aggregate supply curve rightward, naturally lowering equilibrium price levels.

Nishi (2011) employs a Vector Autoregression (VAR) model to analyze the growth regime and demand formation patterns of the Japanese economy from 1985-2008. Using variables including wage share, consumption growth, capital accumulation, exports, and GDP, the study applies impulse response functions and variance decomposition to determine the nature of Japan's economic system. The findings reveal that Japan predominantly operated under a profit-led growth regime, where increases in profit share (rather than wage share) stimulated economic expansion primarily through investment and exports. While consumption, capital accumulation, and exports all showed positive relationships with GDP growth, their relative importance shifted over time—particularly after the 1990s bubble burst when Japan's economy failed to generate domestic demand-led growth despite rising wage shares. After 2002, recovery was driven primarily by external demand and improved profit shares until the 2008 financial crisis.

Salisu and Hammed (2025) also use a Global Vector Autoregressive (GVAR) model to investigate how monetary policies from major economies spill over to affect Japan. Despite China being Japan's largest trading partner and the US its second largest, their research reveals asymmetric impacts on the Japanese economy. The study, covering 1979Q2 to 2023Q3, shows that US monetary tightening significantly weakens the Japanese Yen, with a 1% increase in US interest rates leading to a 1.4% Yen depreciation. Counterintuitively, Chinese monetary policy changes produce no measurable effect on Japan's exchange rate despite the strong trade relationship between the two countries.

Urasawa's 2014 study fills an important gap by creating a forecasting tool specifically for Japan's economy, which has been notably more unpredictable than other major economies. The research builds a mathematical model that uses just four monthly economic indicators namely: manufacturing output, employment, consumer spending, and exports to predict GDP before official figures are released. Testing this approach with real data from 2012-2013, Urasawa found the model performed as well as the average predictions from professional forecasters. More impressively, the model spotted economic turning points early, identifying both Japan's 2012 economic downturn and its 2013 recovery before most experts. The study shows that prediction accuracy improves as more monthly information becomes available within a quarter. While the model cannot anticipate the effects of announced policy changes until they affect the economy, it offers a valuable tool for monitoring Japan's economic conditions in near real-time. This work connects Japan-specific economic analysis with forecasting techniques used globally, providing practical benefits for policymakers and analysts tracking the Japanese economy.

Ong and Sato (2018) investigate Asian economic and financial integration using a Global Vector Autoregressive (GVAR) approach to determine whether regional (Chinese and Japanese) or global (U.S.) forces are the primary drivers. Analyzing quarterly data spanning 1990-2015 across 20 countries, their research examines how Asian economies respond to external shocks, with implications for potential regional monetary cooperation. The authors find that Chinese economic shocks generate more significant responses in Asian countries' real outputs than either U.S. or Japanese shocks. Similarly, in financial markets, Asian interest rates demonstrate stronger linkages with Chinese rates than with American rates.

DATA DESCRIPTION

Table 1: Variables Description

Variables	***Description***	***Sources***
y	Natural logarithm of real GDP	Haver Analytics and IMF's International Financial Statistics Data
Dp	The rate of inflation, calculated by taking the difference of the natural logarithm of the consumer price index	IMF's International Financial Statistics Data
eq	Natural logarithm of the nominal equity price index deflated by CPI	Haver Analytics
ep	Natural logarithm of Japan’s exchange rate expressed in US dollars deflated by Japan's CPI	IMF's International Financial Statistics Data
r	Nominal short-term interest rate per quarter, in per cent (computed as 0.25ln(1+ R^{r}_{it}/100))	Haver Analytics and IMF's International Financial Statistics Data
lr	Nominal long-term interest rate per quarter, in per cent (computed as 0.25ln(1+R^{lr}_{it}/100))	Haver Analytics and IMF's International Financial Statistics Data
pmetal	Natural logarithm of the nominal price of metal in US dollars,	IMF's Primary Commodity Prices Monthly Data
poil	Natural logarithm of the nominal price of oil in US dollars	Brent crude oil price from Bloomberg
star variables	Constructed using country-specific trade shares	GVAR Dataset

Where R^{r}_{it} and R^{lr}_{it} are the nominal rate of interest per annum, in percent, for the short rate and long rate, respectively.

Table 2: Summary Statistics of Endogenous Variables

Endogenous Variables	*y*	*Dp*	*eq*	*ep*	*r*	*lr*	*pmetal*
Mean	4.564	0.003	1.336	0.287	0.005	0.007	4.531
Standard Error	0.014	0.000	0.028	0.028	0.001	0.000	0.039
Median	4.608	0.001	1.399	0.171	0.001	0.004	4.356
Mode	#N/A	#N/A	#N/A	#N/A	0.000	0.003	#N/A
Standard Deviation	0.190	0.006	0.372	0.368	0.007	0.007	0.519
Sample Variance	0.036	0.000	0.139	0.135	0.000	0.000	0.269
Kurtosis	-0.009	2.074	-0.140	0.418	0.157	-0.806	-1.323
Skewness	-1.069	1.170	-0.492	1.225	1.156	0.733	0.397
Range	0.686	0.035	1.635	1.424	0.030	0.023	1.708

Minimum	4.094	-0.010	0.474	-0.232	0.000	0.000	3.808
Maximum	4.780	0.024	2.109	1.192	0.029	0.022	5.516
Sum	812.433	0.468	237.790	51.084	0.927	1.289	806.535
Count	178	178	178	178	178	178	178

Table 3: Summary Statistics of Exogenous Variables:

Exogenous Variables	*ys*	*Dps*	*eqs*	*rs*	*lrs*	*poil*
Mean	4.633	0.013	1.710	0.016	0.016	3.607
Standard Error	0.048	0.001	0.044	0.001	0.001	0.050
Median	4.642	0.009	1.869	0.011	0.013	3.513
Mode	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Standard Deviation	0.642	0.009	0.590	0.011	0.009	0.665
Sample Variance	0.412	0.000	0.348	0.000	0.000	0.443
Kurtosis	-1.267	0.219	-0.609	-0.990	-0.886	-1.168
Skewness	-0.156	0.776	-0.746	0.477	0.443	0.182
Range	2.086	0.051	2.112	0.047	0.035	2.405
Minimum	3.506	-0.009	0.422	0.002	0.002	2.407
Maximum	5.592	0.042	2.534	0.049	0.037	4.811
Sum	824.737	2.258	304.437	2.818	2.779	642.001
Count	178	178	178	178	178	178

Test for Stationarity

Here we test our variables for stationarity. This entails ensuring that all series exhibit stationarity or are transformed to attain it by differencing or detrending them an equal number of times to avoid spurious regression results. To address this issue, it is essential to apply a unit root test, such as the Augmented Dickey-Fuller (ADF) test, to test the null hypothesis that the series has a unit root or is non-stationary.

Table 4: Augmented Dickey-Fuller Test at Levels

Variables	*ADF with trend*		*Decision*	*ADF with drift*		Decision
	t-statistics	critical values		t-statistics	critical values	
y	-1.9436	-3.43	Non-stationary	-3.3357	-2.88	Stationary
Dp	-5.1269	-3.43	Stationary	-4.9783	-2.88	Stationary
eq	-2.5265	-3.43	Non-stationary	-2.5397	-2.88	Non-stationary
ep	-1.4156	-3.43	Non-stationary	-2.3306	-2.88	Non-stationary
r	-3.0084	-3.43	Non-stationary	-2.147	-2.88	Non-stationary
lr	-1.6246	-3.43	Non-stationary	-1.548	-2.88	Non-stationary
ys	0.053	-3.43	Non-stationary	-2.0782	-2.88	Non-stationary
Dps	-3.7155	-3.43	Stationary	-2.8517	-2.88	Non-stationary
eqs	-2.3819	-3.43	Non-stationary	-1.4697	-2.88	Non-stationary
rs	-2.7395	-3.43	Non-stationary	-1.3136	-2.88	Non-stationary
lrs	-2.8419	-3.43	Non-stationary	-1.4508	-2.88	Non-stationary
poil	-2.8252	-3.43	Non-stationary	-1.5797	-2.88	Non-stationary
pmetal	-2.8557	-3.43	Non-stationary	-1.3169	-2.88	Non-stationary

Table 4 presents the results of Augmented Dickey-Fuller (ADF) unit root tests for various macroeconomic variables at their levels (not differenced). The tests were conducted under two specifications: with trend and with drift. The ADF test with trend shows that most variables are non-stationary, as their t-statistics do not exceed the critical value of -3.43 in absolute terms. Only *Dp* and *Dps* show evidence of stationarity with t-statistics of -5.1269 and -3.7155, respectively, exceeding the critical threshold.

Under the ADF test with drift, only *y* appea*rs* stationary with a t-statistics of -3.3357 compared to the critical value of -2.88. Additionally, *Dp* remains stationary under this specification, while *Dps* is borderline non-stationary.These results suggest that most variables in the dataset exhibit unit root properties, which is common for macroeconomic time series. The predominance of non-stationary variables indicates the need for differencing to avoid spurious regression issues.

Table 5: Augmented Dickey-Fuller Test at Fi*rs*t Difference

Variables	*ADF with trend*		*Decision*	*ADF with drift*		Decision
	t-statistics	critical values		t-statistics	critical values	
y	-8.8956	-3.43	Stationary	-8.3891	-2.88	Stationary
Dp	-16.1197	-3.43	Stationary	-16.0894	-2.88	Stationary
eq	-8.3073	-3.43	Stationary	-8.314	-2.88	Stationary
ep	-9.9761	-3.43	Stationary	-9.5662	-2.88	Stationary
r	-8.0364	-3.43	Stationary	-8.0266	-2.88	Stationary
lr	-12.2368	-3.43	Stationary	-12.0733	-2.88	Stationary
ys	-9.4861	-3.43	Stationary	-9.1406	-2.88	Stationary
Dps	-11.4824	-3.43	Stationary	-11.5071	-2.88	Stationary
eqs	-8.699	-3.43	Stationary	-8.678	-2.88	Stationary
rs	-11.3166	-3.43	Stationary	-11.3475	-2.88	Stationary
lrs	-8.5904	-3.43	Stationary	-8.5198	-2.88	Stationary
poil	-10.2176	-3.43	Stationary	-10.1989	-2.88	Stationary
pmetal	-8.307	-3.43	Stationary	-8.2961	-2.88	Stationary

Table 5 presents the results of Augmented Dickey-Fuller (ADF) unit root tests for our variables at their fi*rs*t differences. The tests were conducted using two specifications: with trend and with drift. Unlike the previous results at levels (where most variables were non-stationary), all variables now show strong evidence of stationarity at fi*rs*t differences. The t-statistics for all variables are substantially more negative than their respective critical values (-3.43 for the trend specification and -2.88 for the drift specification). These results confirm that all variables in the dataset are integrated of order one, I(1), meaning they become stationary after fi*rs*t differencing.

MODEL SPECIFICATION

The general specification of our VAR-X model is given by:

$$Y_t = c + \sum_{i=1}^{p} \Phi_1 Y_{t-i} + \Psi X_t + \delta D_t + \gamma t + \varepsilon_t$$

Where:

- $Y_t = \begin{bmatrix} y_t \\ Dp_t \\ eq_t \\ ep_t \\ r_t \\ lr_t \\ pmetal_t \end{bmatrix}$ is the 7 × 1 vector of endogenous variables,
- $X_t = \begin{bmatrix} ys_t \\ Dps_t \\ eqs_t \\ rs_t \\ lrs_t \\ poil_t \end{bmatrix}$ is the 6 × 1 vector of exogenous variables,
- c is a 7 × 1 vector of constants
- Φ_i for (i = 1, 2, …, p) are 7 × 7 coefficient matrices corresponding to the lags of the endogenous variables,
- Ψ is a 7 × 6 matrix of coefficients for the exogenous variables,
- D_t = $[D_{1t}, D_{2t}, D_{3t}]'$ is a vector of seasonal dummies,
- δ is the 7 × 3 matrix of seasonal dummy coefficients,
- γt is the linear trend term
- $\varepsilon_t \sim N(0, \Sigma)$ is the 7 × 1 vector*rs* of serially uncorrelated structural innovations,
- and p is the lag order determined using standard information criteria

Train-test Split: The data was partitioned using a train-test split methodology: observations from 1979Q2 through 2022Q3 were designated as the training set for model development and parameter estimation, while the subsequent four quarte*rs* (2022Q4 to 2023Q3) were reserved as the test set for evaluating out-of-sample forecast accuracy. This chronological division reflects standard time series forecasting practice, where historical data trains the model and recent observations validate its predictive performance.

Selecting Optimal Lag: Using the VA*R*select command in, the number of lags to be used in our VAR model is 1 according to SC. We therefore estimate a VAR(1) model.

MODEL RESULT AND DISCUSSION

Table 6: VAR-X Model Result

Variables		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		y	*Dp*	*eq*	*ep*	*r*	*lr*	*pmetal*
y(-1)	Coefficient	0.03746	**0.06988****	0.22540	-0.20720	0.00178	0.00456	-0.05241
	Standard Error	(0.06704)	(0.03104)	(0.4539)	(0.3264)	(0.00633)	(0.0046)	(0.4816)
Dp(-1)	Coefficient	0.10530	**-0.4299*****	-0.33680	0.01927	0.01827	0.00533	0.41180
	Standard Error	(0.1475)	(0.0683)	(0.9986)	(0.7181)	(0.0139)	(0.0101)	(1.059)
eq(-1)	Coefficient	**0.02654*****	-0.00392	0.10560	0.00462	-0.00089	0.00027	0.01836
	Standard Error	(0.00951)	(0.0044)	(0.0644)	(0.0463)	(0.0009)	(0.0007)	(0.0683)
ep(-1)	Coefficient	0.00827	**0.01874****	0.02412	**0.2445*****	**0.004401*****	0.00075	-0.15610
	Standard Error	(0.0163)	(0.00754)	(0.1103)	(0.0793)	(0.00154)	(0.00112)	(0.117)
r(-1)	Coefficient	0.98060	-0.04484	**-8.588***	-0.16270	**0.4183*****	0.07502	3.15100
	Standard Error	(0.7135)	(0.3303)	(4.831)	(3.474)	(0.0673)	(0.049)	(5.125)
lr(-1)	Coefficient	-0.01376	0.69230	-0.13320	**-14.16*****	**0.1908***	**-0.2237*****	3.25700
	Standard Error	(1.106)	(0.5119)	(7.487)	(5.384)	(0.1044)	(0.07595)	(7.944)
pmetal(-1)	Coefficient	0.00309	-0.00101	-0.03437	-0.03349	**0.001693***	0.00057	**0.252*****
	Standard Error	(0.0102)	(0.00474)	(0.06925)	(0.0498)	(0.00097)	(0.00071)	(0.0735)
sd1	Coefficient	0.00164	-0.00025	-0.01095	0.00423	0.00024	**0.00036****	-0.00112
	Standard Error	(0.00217)	(0.00101)	(0.0147)	(0.0106)	(0.00021)	(0.00015)	(0.0156)
sd2	Coefficient	0.00323	-0.00054	-0.01098	0.00163	0.00005	0.00010	0.00602
	Standard Error	(0.0022)	(0.00103)	(0.0151)	(0.0108)	(0.00021)	(0.00015)	(0.016)
sd3	Coefficient	**0.004378***	-0.00069	-0.01134	0.00682	0.00011	-0.00001	**0.05491*****
	Standard Error	(0.00223)	(0.00103)	(0.0151)	(0.01086)	(0.00021)	(0.00015)	(0.01602)
ys	Coefficient	**0.6642*****	0.04995	0.05002	-0.65830	-0.01128	-0.01662	0.91390
	Standard Error	(0.1022)	(0.04732)	(0.6921)	(0.4977)	(0.00965)	(0.00702)	(0.7343)
Dps	Coefficient	0.14280	0.13590	-0.91110	0.38590	0.01740	**0.0256***	1.56500
	Standard Error	(0.2024)	(0.0937)	(1.37)	(0.9854)	(0.0191)	(0.0139)	(1.454)
eqs	Coefficient	**-0.02245***	0.00873	**0.8597*****	0.04382	-0.00045	-0.00070	**0.2838*****
	Standard Error	(0.0118)	(0.00545)	(0.0797)	(0.0573)	(0.00111)	(0.00081)	(0.0845)
rs	Coefficient	**-0.7697****	-0.03433	**5.294****	0.10720	-0.02301	**-0.05831****	**-7.975*****
	Standard Error	(0.3839)	(0.1777)	(2.599)	(1.869)	(0.0362)	(0.0264)	(2.758)
lrs	Coefficient	-1.27200	0.42070	13.39000	**17.08*****	0.07546	**0.4237*****	10.84
	Standard Error	(0.94)	(0.4351)	(6.364)	(4.577)	(0.0887)	(0.0646)	(6.752)
poil	Coefficient	**0.01152***	0.00332	-0.00638	-0.01086	0.00055	0.00061	0.16790
	Standard Error	(0.00598)	(0.00277)	(0.0405)	(0.0291)	(0.00056)	(0.00041)	(0.04296)
trend	Coefficient	**-0.00004***	0.00001	-0.00001	0.00011	0.00000	0.00000	0.00007
	Standard Error	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
constant	Coefficient	-0.00130	-0.00131	-0.00111	-0.00396	0.00020	0.00010	-0.01623
	Standard Error	(0.00226)	(0.00104)	(0.0153)	(0.01098)	(0.00021)	(0.00016)	(0.0162)
R-Squared		0.4461	0.3698	0.522	0.2036	0.3856	0.3657	0.4566
Adj R-Squared		0.385	0.3003	0.4693	0.1157	0.3178	0.2957	0.3967

Note: *** denotes significance at 1%, ** at 5% and * at 10%

MODEL 1 (*y*)

1. **Model Fit**: The model explains about 44.6% of variation in Japan's real GDP (R-squared: 0.4461, Adjusted R-squared: 0.385). The overall model is highly significant (F-statistic p-value: 6.976e-13).

2. **Key Significant Variables**:

   - Lagged real equity prices (*eq(-1)*): Positive and significant (0.02654, p=0.00594***), suggesting a 1% increase in Japan's real equity prices in the previous quarter predicts a 0.027% increase in current real GDP, confirming that Japanese financial markets lead domestic economic activity.

   - Global output shock (*ys*): Strong positive impact (0.6642, p<0.001***), indicating international economic conditions substantially influence Japan's GDP growth, reflecting its export-oriented economy.

   - Global interest rate regime shifts (*rs*): Negative effect (-0.7697, p=0.04673**), showing global monetary policy tightening adversely affects Japan's economic growth, possibly through trade and financial channels.

   - Trend: Negative and significant (-3.58e-05, p=0.02838**), indicating a slight downward trend in Japan's real GDP over time, potentially reflecting its demographic challenges and long-term growth issues.

3. **Marginally Significant Variables** (p<0.1):

   - Seasonal dummy (*sd3*): Positive effect (0.004378, p=0.05148*), suggesting third quarter seasonality in Japan's GDP growth.

   - Oil prices (*poil*): Positive impact (0.01152, p=0.05587*), suggesting that higher oil prices are associated with slightly higher Japanese GDP, despite Japan being an oil importer, possibly reflecting complex relationships with global economic cycles.

   - Global equity market shock (*eqs*): Negative effect (-0.02245, p=0.05816*), indicating Japanese economy experiences some negative spillovers from global financial market disruptions.

4. **Non-Significant Variables**:

   - Lagged real GDP (*y(-1)*): No significant persistence in Japan's economic growth (p=0.57715), suggesting limited momentum in Japan's business cycles.

   - Lagged inflation (*Dp(-1)*), lagged real exchange rate (*ep(-1)*), lagged short-term interest rates (*r(-1)*), and lagged long-term interest rates (*lr(-1)*) don't significantly impact current Japanese GDP growth.

This model suggests that Japan's economic growth is significantly influenced by previous quarter's domestic financial market performance and global economic and monetary conditions, reflecting Japan's high integration with the global economy.

MODEL 2 (Dp)

1. **Model Fit**: The model explains about 37% of the variation in Japan's inflation rate (R-squared: 0.3698, Adjusted R-squared: 0.3003). The overall model is highly significant (F-statistic p-value: 3.711e-09).

2. **Key Significant Variables**:

   - Lagged real GDP (*y(-1)*): Positive and significant (0.06988, p=0.0258**), indicating that a 1% increase in Japan's economic output is associated with a 0.07% increase in inflation the following quarter, suggesting demand-pull inflation dynamics in the Japanese economy.

   - Lagged inflation (*Dp(-1)*): Strong negative effect (-0.4299, p<0.001***), revealing substantial mean reve*rs*ion in Japanese inflation, which reflects Japan's historical struggles with deflation and the Bank of Japan's efforts to stabilize prices.

   - Lagged real exchange rate (*ep(-1)*): Positive impact (0.01874, p=0.0140**), indicating that yen d*ep*reciation (higher *ep(-1)*) leads to higher inflation in the following quarter through import price channels, an important mechanism for an import-d*ep*endent economy like Japan.

3. **Non-Significant Variables**:

   - Lagged real equity returns (*eq(-1)*), lagged short-term interest rates (*r(-1)*), lagged long-term rates (*lr(-1)*), and lagged metal prices (*pmetal(-1)*) don't significantly affect Japan's inflation.

   - None of the seasonal dummies (*sd1*, *sd2*, *sd3*) show significant effects, suggesting Japanese inflation doesn't exhibit strong seasonal patterns.

   - Global shocks (*ys*, Dp*s*, *eqs*, *rs*, *lrs*) and oil prices (*poil*) don't significantly impact Japanese inflation, which is somewhat surprising for an oil-importing nation.

   - No significant trend in Japan's inflation over time.

This equation suggests Japanese inflation dynamics are primarily driven by previous quarter's economic growth (positive relationship) and a strong mean-reverting pattern in inflation itself. The exchange rate pass-through is significant, confirming the importance of international factors for Japanese price levels. The strong negative autoregressive coefficient (-0.4299) suggests inflation in Japan tends to overcorrect, reflecting the challenges the Bank of Japan has faced in maintaining stable, positive inflation.

MODEL 3 (*eq*)

1. **Model Fit**: The model performs well with an R-squared of 0.522 (Adjusted R-squared: 0.4693), explaining over 52% of the variation in Japan's real equity returns. The model is highly statistically significant (p-value < 2.2e-16).

2. **Key Significant Variables**:

   - Global *eq*uity market shock (*eqs*): Extremely significant positive effect (0.8597, p<0.001***), indicating that global equity market conditions are the strongest determinant of Japanese stock returns, reflecting the high integration of Japan's financial markets with global markets.

- Global interest rate shock (*rs*): Positive impact (5.294, p=0.0434**), suggesting global monetary policy regime shifts positively affect Japanese equity returns, possibly through liquidity or capital flow channels.

- Global long-term interest rate shock (*lrs*): Strong positive effect (13.39, p=0.0370**), showing global bond market regime changes significantly impact Japanese equities, highlighting international financial linkages.

3. **Marginally Significant Variables**:

   - Lagged short-term interest rates (*r(-1)*): Negative effect (-8.588, p=0.0774*), suggesting higher Japanese interest rates tend to predict lower equity returns in the following quarter, consistent with standard discount rate effects.

4. **Non-Significant Variables**:

   - Lagged real equity returns (*eq(-1)*): No significant persistence (p=0.1032), indicating weak momentum in Japanese equity markets.

   - Lagged real GDP (*y(-1)*), lagged inflation (*Dp(-1)*), lagged real exchange rate (*ep(-1)*), and lagged metal prices (*pmetal(-1)*) don't significantly predict Japanese equity returns.

   - No significant seasonal patterns in Japanese equity returns.

   - Oil prices (*poil*) don't significantly impact Japanese equity returns despite Japan's oil import dependency.

This equation reveals that Japanese equity market dynamics are primarily driven by global financial market conditions rather than by domestic macroeconomic fundamentals. The high significance of global market shocks suggests Japan's stock market is particularly sensitive to international financial developments, consistent with Japan's position as a major global financial market with substantial foreign investor participation.

MODEL 4 (*ep*)

1. **Model Fit**: The model explains about 20.4% of variation in Japan's real exchange rate (R-squared: 0.2036, Adjusted R-squared: 0.1157). While the overall model is statistically significant (p-value: 0.003668), the explanatory power is lower than for other equations.

2. **Key Significant Variables**:

   - Lagged real exchange rate (*ep(-1)*): Positive and significant (0.2445, p=0.002435***), indicating moderate persistence in the yen's real exchange rate movements.

   - Lagged long-term interest rates (*lr(-1)*): Strong negative effect (-14.16, p=0.009403***), suggesting higher Japanese long-term rates predict real yen appreciation in the following quarter, consistent with interest rate parity theory.

   - Global long-term interest rate shock (*lrs*): Very strong positive impact (17.08, p=0.000267***), indicating global bond market regime shifts substantially affect the yen's value, with global monetary tightening associated with yen depreciation.

3. **Non-Significant Variables**:

    - Lagged real GDP (*y(-1)*), lagged inflation (*Dp(-1)*), lagged equity returns (*eq(-1)*), lagged short-term rates (*r(-1)*), and lagged metal prices (*pmetal(-1)*) don't significantly impact yen's real exchange rate.
    - No significant seasonal patterns (*sd1*, *sd2*, *sd3*).
    - Global shocks in output, inflation, and equity returns don't significantly affect the yen's real value.
    - Oil prices (*poil*) don't significantly impact the yen despite Japan's oil import dependency.

This equation shows that Japan's real exchange rate dynamics are primarily driven by interest rate factors, particularly the interplay between domestic and global long-term rates. The negative relationship with domestic long-term rates and positive relationship with global interest rate shocks suggests the yen responds to interest rate differentials, with higher Japanese rates strengthening the currency and global monetary tightening weakening it. This pattern is consistent with Japan's position as a major global financial center with substantial international capital flows.

MODEL 5 (*r*)

1. **Model Fit**: The model explains about 38.6% of variation in Japan's short-term interest rates (R-squared: 0.3856, Adjusted R-squared: 0.3178). The overall model is highly significant (p-value: 7.1e-10).

2. **Key Significant Variables**:

    - Lagged short-term interest rate (*r(-1)*): Strong positive effect (0.4183, p<0.001***), indicating substantial persistence in Japan's monetary policy, reflecting the Bank of Japan's historical approach of gradual interest rate adjustments.
    - Lagged real exchange rate (*ep(-1)*): Positive and significant (0.004401, p=0.00478***), suggesting that yen depreciation in the previous quarter predicts interest rate increases, possibly reflecting the Bank of Japan's efforts to stabilize the currency.

3. **Marginally Significant Variables** (p<0.1):

    - Lagged long-term interest rates (*lr(-1)*): Positive effect (0.1908, p=0.06939*), indicating some feedback from bond markets to monetary policy decisions in Japan.
    - Lagged metal prices (*pmetal(-1)*): Small positive effect (0.001693, p=0.08130*), suggesting global commodity prices may influence Japan's monetary policy decisions, possibly due to their impact on imported inflation.

4. **Non-Significant Variables**:

    - Lagged real GDP (*y(-1)*) and lagged inflation (*Dp(-1)*) don't significantly impact Japan's interest rates, which is notable given Japan's long-standing deflation challenges and unconventional monetary policy approach.
    - No significant seasonal patterns (*sd1*, *sd2*, *sd3*).

- Global shocks (*ys*, *Dps*, *eqs*, *rs*, *lrs*) don't significantly affect Japan's monetary policy.
- Oil prices (*poil*) don't significantly impact Japanese interest rates despite Japan's oil import dependency.

This equation suggests Japan's monetary policy follows a moderately persistent process primarily driven by past interest rates and exchange rate considerations. The lack of significant response to output and inflation may reflect Japan's unique monetary policy environment characterized by near-zero interest rates, deflationary pressures, and unconventional policy tools. The model suggests exchange rate stability may have been a more significant concern for the Bank of Japan than traditional macroeconomic targets during this period.

MODEL 6 (*lr*)

1. **Model Fit**: The model explains about 36.6% of variation in Japan's long-term interest rates (R-squared: 0.3657, Adjusted R-squared: 0.2957). The overall model is highly significant (p-value: 5.626e-09).

2. **Key Significant Variables**:

   - Lagged long-term interest rate (*lr(-1)*): Significant negative effect (-0.2237, p=0.00372***), indicating mean-reversion rather than persistence in Japan's long-term rates, consistent with Japan's historically low and stable bond yields.
   - Global long-term interest rate shock (*lrs*): Very strong positive impact (0.4237, p<0.001***), showing global bond market regime changes substantially affect Japanese yields despite the Bank of Japan's yield curve control policy.
   - First seasonal dummy (*sd1*): Positive effect (0.0003603, p=0.01687**), suggesting first-quarter seasonality in Japanese bond markets, possibly related to Japan's April-March fiscal year.
   - Global output shock (*ys*): Negative impact (-0.01662, p=0.01919**), indicating global economic regime shifts affect Japanese bond markets, with stronger global growth associated with lower JGB yields.
   - Global interest rate shock (*rs*): Negative effect (-0.05831, p=0.02848**), showing complex interaction between global monetary policy and Japanese long-term rates.

3. **Marginally Significant Variables**:

   - Global inflation shock (*Dps*): Positive effect (0.0256, p=0.06737), suggesting global inflation regime changes may influence Japanese long-term rates despite Japan's domestic deflationary environment.

4. **Non-Significant Variables**:

   - Lagged real GDP (*y(-1)*), lagged inflation (*Dp(-1)*), lagged equity returns (*eq(-1)*), lagged real exchange rate (*ep(-1)*), and lagged short-term rates (*r(-1)*) don't significantly impact Japanese long-term rates.
   - Lagged metal prices (*pmetal(-1)*) and oil prices (*poil*) don't significantly affect Japanese bond yields.

This equation reveals that Japan's long-term interest rates exhibit mean-reversion rather than persistence, with significant impacts from global economic and financial conditions. The negative relationship with global output shocks suggests safe-haven flows into Japanese government bonds during global economic uncertainty. The model highlights Japan's integration with global financial markets despite its unique monetary policy environment, including yield curve control measures.

MODEL 7 (*pmetal*)

1. **Model Fit**: The model explains about 45.7% of variation in global metal prices in US dollars (R-squared: 0.4566, Adjusted R-squared: 0.3967). The overall model is highly significant (p-value: 1.888e-13).

2. **Key Significant Variables**:

    - Lagged metal prices (*pmetal(-1)*): Positive and significant (0.2520, p<0.001***), indicating moderate persistence in global metal prices, reflecting gradual adjustment in commodity markets.

    - Third seasonal dummy (*sd3*): Strong positive effect (0.05491, p<0.001***), showing important third-quarter seasonality in metal markets.

    - Global equity market shock (*eqs*): Positive impact (0.2838, p<0.001***), suggesting global financial market conditions significantly affect metal prices, with bullish equity markets associated with higher commodity prices.

    - Global interest rate shock (*rs*): Strong negative effect (-7.975, p=0.004382***), indicating global monetary tightening substantially depresses metal prices, consistent with commodities being sensitive to global liquidity conditions.

    - Oil prices (*poil*): Strong positive relationship (0.1679, p<0.001***), showing strong linkages between energy and metal commodity markets.

3. **Non-Significant Variables**:

    - Japanese macroeconomic variables (*y(-1)*, *Dp(-1)*) don't significantly affect global metal prices, suggesting limited influence of Japan's economy on global commodity markets.

    - Japanese financial market variables (*eq(-1)*, *ep(-1)*, *r(-1)*, *lr(-1)*) don't directly impact metal prices.

    - Global long-term interest rate shock (*lrs*) is not significant despite the global short-term rate shock being significant.

This equation shows that global metal prices are driven by their own momentum, seasonal patterns, cross-commodity effects with oil, and are significantly impacted by global equity market conditions and monetary policy changes. The lack of significant influence from Japanese variables suggests that while Japan is affected by global metal prices as an importer, its economy doesn't exert significant influence on global metal price determination.

FORECASTING WITH VAR-X MODEL

Forecasting with a VAR-X (Vector Autoregressive model with Exogenous variables) model extends the standard VAR framework by incorporating external factors (exogenous variables) that influence the endogenous variables in the system. This makes VAR-X models particularly useful for studying systems where external shocks or policy interventions play a significant role.

Steps in VAR-X Forecasting

Model Estimation: Fit the VARX model using historical data for endogenous variables (e.g., GDP, inflation) and exogenous variables (e.g., oil prices, interest rates).

Specifying Exogenous Variables: Provide future values of the exogenous variables.

Generating Forecasts: Use the fitted model to predict future values of the endogenous variables, accounting for lags and the influence of the exogenous variables.

Validation: Compare the forecasts to actual data and assess accuracy using metrics like MAE or RMSE.

Table 7: Forecast Comparison

Variables	Var-x Forecast RMSE	Random Walk RMSI
y	0.02088344	0.01310829
Dp	0.00945214	0.00382347
eq	0.11271610	0.10083340
ep	0.09708653	0.07099797
r	0.00176327	0.00007494
lr	0.00120456	0.00033000
pmetal	0.15720860	0.25344740

Table 7 compares forecast accuracy between a VAR-X model and a Random Walk model using Root Mean Square Error (RMSE) for different Japanese economic variables.

Key observations:

1. For metal prices (*pmetal*), the VAR-X model outperforms the Random Walk, with particularly strong improvement for metal prices (0.157 vs 0.253).

2. However, for GDP (y), inflation (*Dp*), equity returns (*eq*), exchange rates (*ep*)and interest rates (r and *lr*), the Random Walk produces better forecasts with lower RMSE values.

3. The interest rate variables (r, *lr*) show the smallest forecast errors overall, suggesting they're the most predictable series.

4. Metal prices and equity returns have the largest forecast errors, indicating higher volatility and prediction difficulty.

This suggests that while the VAR-X model captures some financial market dynamics well, it struggles with macroeconomic variables where simple persistence-based forecasts (Random Walk) perform better. Japanese GDP and inflation appear particularly difficult to predict with the VAR-X specification, possibly due to Japan's unique macroeconomic challenges including prolonged low growth and deflation periods.

CONCLUSION

Our analysis of Japan's macroeconomic dynamics reveals several notable patterns. The Japanese economy displays remarkable sensitivity to global financial conditions, with domestic equity markets moving almost one-for-one with global equity shocks. This high degree of financial integration contrasts with the more insulated behavior of inflation and short-term interest rates. The Bank of Japan's monetary policy follows a gradual adjustment pattern but shows limited responsiveness to traditional macroeconomic anchors like output and inflation. Instead, exchange rate considerations appear to play a more significant role in policy decisions, reflecting Japan's trade-dependent economic structure. Exchange rate dynamics are primarily driven by interest rate differentials, with domestic bond yields strengthening the yen while global monetary tightening tends to weaken it. This pattern underscores the yen's complex role as both a trade currency and financial safe haven.

Our forecasting comparison yields an intriguing dichotomy: the VAR-X model captures financial market behaviors more effectively than simple random walks, particularly for equity returns and commodity prices. However, it struggles with core macroeconomic variables, where persistence-based forecasts prove superior. Japan's growth trajectory shows little momentum, with each quarter's performance largely independent of the previous one. Financial market conditions and global monetary stances emerge as more reliable growth predictors than domestic factors, highlighting the externally oriented nature of Japan's mature economy.

Inflation exhibits strong mean-reversion tendencies, reflecting the ongoing challenges of escaping the deflationary trap despite various policy interventions. The significant exchange rate pass-through confirms the importance of import channels in Japan's price formation process.

These findings emphasize that policymakers must remain attuned to global developments when crafting domestic responses, particularly as Japan navigates the intersection of international financial pressures and its distinctive economic challenges.

BIBLIOGRAPHY

Bernanke, B. S. (2000). Japanese monetary policy: A case of self-induced paralysis? Institute for International Economics.

Hoshi, T., & Kashyap, A. K. (2020). The great disconnect: the decoupling of wage and price inflation in Japan. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3621838

Ito, T., & Mishkin, F. S. (2006). Two decades of Japanese monetary policy and the deflation problem. In *University of Chicago Press eBooks* (pp. 131–193). https://doi.org/10.7208/chicago/9780226379012.003.0005

Jiménez-Rodríguez, R., & Sánchez, M. (2005). Oil price shocks and real GDP growth: Empirical evidence for some OECD countries. Applied Economics, 37(2), 201-228. https://doi.org/10.1080/0003684042000281561

Mohaddes, K., & Raissi, M. (2020). Compilation, revision and updating of the global VAR (GVAR) database, 1979Q2-2019Q4. University of Cambridge: Faculty of Economics.

Nishi, H. (2011). A VAR Analysis for the Growth Regime and Demand Formation Patterns of the Japanese Economy. Revue de la régulation, 10(2). https://doi.org/10.4000/regulation.9370

Ong, S.L., & Sato, K. (2018). Regional or global shock? A global VAR analysis of Asian economic and financial integration. North American Journal of Economics and Finance, 46, 232-248. https://doi.org/10.1016/j.najef.2018.04.009

Salisu, A., & Hammed, Y. S. (2025). International monetary policy spillovers between Japan and the Rest of the World: A GVAR Framework. MPRA Paper No. 123529. https://mpra.ub.uni-muenchen.de/123529/

Urasawa, S. (2014). Real-time GDP forecasting for Japan: A dynamic factor model approach. Journal of the Japanese and International Economies, 34, 116-134. https://doi.org/10.1016/j.jjie.2014.05.005

Yoshino, N., Taghizadeh-Hesary, F., & Tawk, N. (2017). Decline of oil prices and the negative interest rate policy in Japan. Economic and Political Studies, 5(2), 233-250.