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Effect of Exchange Rate Path-through on Inflation: Recent Japanese Case

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Abstract
After the burst of the bubble economy in the mid-1990s, when stock and land prices plummeted in Japan, the country had been in a deflationary trend for about 30 years, with the inflation rate hovering around 0%. In 2022, however, sudden increases in the prices of food and utilities, coupled with little increase in wages, made life difficult for people. The beginning of the price increase is attributed to Russia`s invasion of Ukraine in February 2022. This crisis in Ukraine caused food and energy prices to rise. In addition, the interest rate differential between the U.S. and Japan had widened, Japanese yen weakened, and import prices rose, leading to a broad-based price increase in Japan. Moreover, in 2022, the Japanese government announced the "With Corona" policy, which played a pivotal role in both preventing the spread of infection and promoting economic activity, leading to some recovery in economic activity and an acceleration of labor shortages. This was followed by a movement to raise wages. The purpose of this study is to examine the factors behind price increases in Japan. While many believe that the weak yen is the biggest factor behind the price increases, this study uses statistical analysis to test this view. Empirical analyses show that the depreciation of the yen led to higher prices in Japan, but no significant relationship was found between prices and the industrial production index, nor between prices and the policy interest rate. Furthermore, there was no evidence that wage increases caused price increases.

Keywords: Depreciation, Exchange Rate, Inflation, Japan, Yen

1. Introduction

In Japan, after the burst of the ‘bubble’ economy in the mid-1990s, when stock and land prices soared, the country had experienced deflationary pressures for about 30 years, with the inflation rate being around 0%. In 2022, however, it exceeded 2% year-on-year. Sudden increases in the prices of food and utilities, coupled with little increase in wages, made many people’s lives difficult.

The beginning of the price increase is attributed to Russia`s invasion of Ukraine in February 2022. This crisis in Ukraine caused food and energy prices to rise. In addition, the interest rate differential between the U.S. and Japan had widened (the U.S. and Europe raised their interest rates while Japan's remaining near zero), the yen weakened, and import prices rose, leading to a broad-based price increase in Japan, according to the prevailing view. Moreover, in 2022, the Japanese government announced the "With Corona" policy, which played a pivotal role in

both preventing the spread of infection and promoting economic activity, leading to some recovery in economic activity and an acceleration of labor shortages. This was followed by a movement to raise wages, especially in large companies, which continues to this day.

The purpose of this paper is to examine the factors behind price increases in Japan. While many believe that the weak yen is the biggest factor behind recent price increases, this study uses statistical analyses to examine this view. This study is organized as follows. Section 2 reviews existing studies that examine the relationship between prices and exchange rates. Section 3 presents empirical methods for investigating the causes of inflation/deflation. Based on these methods, empirical estimations are conducted and the results are examined in Section 4. Finally, section 5 provides a brief conclusion.

2. Existing Studies

The Bank of Japan (BOJ) ended its negative interest rate policy at the meeting on March 19. This will be the first time in 17 years, since February 2007, that the BOJ has raised the policy interest rate. The policy interest rate was adjusted to 0-0.1%. In a statement after the policy meeting, the BOJ said it would aim to keep the overnight average call rate to remain at around 0-0.1% from March 21. Until then, the BOJ had applied a negative interest rate of 0.1% to a portion of the current accounts deposited with the BOJ by banks and other financial institutions. As for long-term Japanese government bonds, the BOJ decided to continue to purchase them at roughly the same pace as in the past. The Bank also ended new purchases of exchange-traded funds (ETFs) and real estate investment trusts (REITs), which it began in 2010 and has significantly increased since 2013. The Bank also removed its forward guidance, which had stated, among other things, that it would take additional monetary easing measures without hesitation if necessary.

The BOJ aims to achieve its 2% price stability target with wage increases. Governor Kazuo Ueda stated like that once we reach a situation where the realization of the target is foreseeable, we will consider whether or not to continue with the easing measures. He had said that the spring labor negotiations were one of the main points for the decision to change its monetary policy. The 2012 spring labor negotiations, released by RENGO on March 15, showed a wage increase of 5.28 percent, the first time in 33 years since 1991 that it exceeded 5 percent.

There are a lot of studies that examine the relationship between prices and exchange rates. Shioji (2015) showed that exchange rate pass-through to prices, once thought to be almost extinct, has rebounded strongly in recent years. Lau & Yip (2020) found that exchange rate channels have a larger and more positive impact on inflation in the long run than in the short run. Sasaki et al. (2022) showed that exchange rate pass-through (ERPT) affects import prices, domestic producer prices, and consumer prices. Kurihara et al. (2022) found domestic prices in Japan rise due to the depreciation of the yen driven by an increase in crude oil and resource energy prices. Valogo et al. (2023) showed that the results of the theoretical ERPT model indicate that depreciation greater than 0.70% per month introduces a pass-through inflationary effect in Ghana. On the other hand, some studies do not confirm a relationship between prices and exchange rates. Cheng et al. (2006-2007) found no significant relationship between consumer prices and exchange rates.

There are several related studies on this issue. Ryou et al. (2019) showed that using Qual VAR and TVP VAR, the QE (quantity easing) and QQE (quality and quantity easing) policies are only successful in raising Japan's CPI (consumer price index) in the QQE period. Prasertnukul et al. (2010) showed that introducing inflation targeting helps achieve the goals of inflation stability by reducing ERPT and its variability.

However, there are few papers dealing with the recent situation in Japan. The main reason for this may be that inflation has only emerged from deflation in the past two years, and even this inflationary trend is not firm. In addition, while there seems to be a growing consensus that the weak yen is main the cause of price increases, other factors may contribute. Rising wages are one such factor. This paper provides answers to these questions.

3. Empirical method to examine the reason for inflation

First of all, the main variables that are used in this study are checked. The variables are consumer prices (2020=100), Exchange rate (yen per US dollar), and industrial production (2022=100) in Table 1. The data are sourced from International Financial Statistics (IMF). The sample period is from January 2020 to the latest October 2024. All of the data are monthly.

Table 1: Statistics descriptions

	Consumer price (Japan)	Consumer price (US)	Yen-Dollar Exchange rate	Industrial production (Japan)
Mean	102.9690	108.5870	127.1045	103.1741
Median	101.8000	107.3651	129.6114	103.9500
Maximum	109.5000	115.0642	157.8211	120.1000
Minimum	99.1000	104.5175	103.6961	80.0000
Std. Dev.	3.3037	3.4631	18.1969	7.6706
Skewness	0.4942	0.4777	0.1344	-0.3235
Kurtosis	1.7589	1.7185	1.4379	3.4330
Jarque-Bera	6.0831	6.1749	6.0711	1.4649
Probability	0.0477	0.0456	0.0480	0.4807
Sum	5972.2000	6298.0460	7372.0600	5984.1000
Sum Sq. Dev.	622.1241	683.6381	18874.4200	3353.8110
Observations	58	58	58	58

It would be necessary to check correlation coefficients among variables. The results are shown in Table 2.

Table 2: Correlation coefficients among variables

	Consumer price (Japan)	Consumer price (US)	Exchange rate	Industrial production	Policy interest rate
Consumer price (Japan)	1	0.9997	0.9403	-0.0233	0.6574
Consumer price (US)	0.9997	1	0.9420	-0.0254	0.6513
Exchange rate	0.9403	0.9420	1	0.0568	0.5091
Industrial production	-0.0233	-0.0254	0.0568	1	-0.0298
Policy interest rate	0.657	0.6513	0.5091	-0.029	1

The correlation coefficients between prices and exchange rates are high as expected. Interestingly the correlations between prices and interest rates are high. However, the correlation between prices and interest rates is negative which is unexpected. These issues are addressed in Section 4 below.

To examine the deterministic elements of inflation in Japan, this equation is regressed at first.

$$Price = a + b1\ industrial\ production + b2\ industrial\ production(-1) + b3\ exchange\ rate + b4\ exchange\ rate(-1) + b5\ policy\ interest\ rate + b6\ policy\ interest\ rate(-1) + \varepsilon \quad (A)$$

This equation (A) is based on Aleem & Lahiani (2014) and Valogo et al. (2023), who examine the effect of exchange rate pass-through on inflation. The inclusion of industrial production explains the effect of domestic production fluctuations on prices. Pinto & Angelo (2005) found impulse response analysis showed the BOJ's sensitivity not only to inflation and the output gap, but also to the exchange rate. In this study, the US price is assumed to affect domestic (Japanese) prices through the exchange rate, so it is omitted. The policy rate is included in the equation. Lau & Yip (2020) showed that the inflationary impact of the interest rate channel is significant. The lags of the explanatory variables are included to evaluate how past movements influence domestic inflation.

ε is the error term, which is assumed to be normally distributed with a constant and mean zero. The sample period includes the full period from January 2020-October 2024, the period of negative policy interest rates from January 2020-January 2024, and the period of significant depreciation (over 140yen/dollar) from April 2023-April 2024.

Although the period following the shift to positive policy interest rates should be included for estimation, it is omitted due to the short length of the sample period.

Equation (A) is also used to examine the impulse response. In particular, the effects of exchange rate and policy rate on inflation should be noted.

This study focuses on the influence of the exchange rate on domestic inflation. Therefore, the inclusion of only one variable, the exchange rate, should be examined. The equation is specified as (B). The case of using GMM (generalized method of moments) is also examined.

$$Price = a + b\ Exchange\ rate(-1) + \varepsilon \quad (B)$$

Causality is important in studying the relationship between price and exchange rate. It may be important to consider the theory of purchasing power parity. Granger causality is used to test the issue. In addition, this study is divided into three sample periods: The negative/positive interest rate period and large depreciation period. To take this issue into account, the Chow break point test is used.

Finally, wage is included to estimate the deterministic elements of prices. Regarding wage increases for FY2024 (starting April 2024), the labor organization RENGO announced that the average wage increase for 5,284 companies was 5.10%, the highest rate above 5% in 33 years since 1991. On the other hand, the average wage increase rate for 3816 small and medium-sized enterprises (SMEs) with less than 300 employees was 4.45%. This is also the first time in 32 years since 1992, but it is 0.79 percentage points lower than that of large enterprises with 1,000 or more employees. It has been pointed out that the reason for the lower rate among small and medium-sized enterprises compared to large enterprises is that they were not able to fully pass on price increases to their customers. The equation of this effect is regressed as the simple equation (C).

$$Price = a + b\ wage(-1) + \varepsilon \quad (C)$$

According to these methods, empirical analyses are conducted and the results are examined in the following section 4.

4. Empirical results and the interpretations

The regression results of equation (A) are in Table 3, Table 4, and Figure 1. (1), (2), and (3) correspond to the sample periods explained in Section 3. Equations (4) and (5) represent the full sample period.

Table 3: Regression analyses (independent variable: Japanese consumer price)

	(1)	(2)	(3)
Sample period	2020.1-2024.10	2020.1-2024.3	2023.6-2024.10
C	86.9803***	86.3167***	96.5259***
	(39.6880)	(39.6502)	(15.7159)
Industrial production	-0.0157	-0.0202	0.0029
	(-1.0527)	(-1.3428)	(0.1138)
Industrial production(-1)	-0.0160	-0.0182	0.0052
	(-1.0780)	(-1.2077)	(0.2282)
Exchange rate	0.0508	0.0233	0.0296
	(1.4492)	(0.5312)	(0.8206)
Exchange rate(-1)	0.1051***	0.1390***	0.0369
	(2.9201)	(3.2515)	(0.9897)
Policy interest rate	1.9608		1.8879

	(0.5391)		(0.6731)
Policy interest rate(-1)	5.4553		5.0040*
	(1.4311)		(1.8277)
Adjusted R-squared	0.9362	0.9081	0.8335
S.E. of regression	0.8373	0.8280	0.5081
Sum squared resid	35.0615	30.8563	2.5816
Log likelihood	-67.0300	-58.8798	-8.1014
F-statistic	138.0572	122.0703	14.3579
Prob(F-statistic)	0.0000	0.0000	0.0002
Akaike info criterion	2.5975	2.5551	1.7766
Schwarz criterion	2.8484	2.7463	2.1197
Hannan-Quinn criterion	2.6950	2.6280	1.8107
Durbin-Watson stat	0.3599	0.3732	0.6386

Note: ***, **, and * are significant at 1, 5, and 10% respectively. Parentheses are t-statistic. From 2020.1 to 2024.3, policy interest rate was same.

Table 4: Regression analyses

	(4)	(5)
Sample period	2020.1-2024.10	2020.1-2024.10
Variable	Consumer price	Exchange rate
Consumer price(-1)	0.8865***	0.4478
	(20.2982)	(0.8666)
Industrial production(-1)	0.0058	-0.023157
	(1.1495)	(-0.3846)
Exchange rate(-1)	0.023692***	0.9371***
	(3.3929)	(11.3444)
Policy interest rate(-1)	0.8695	-9.2618
	(1.5222)	(-1.3705)
C	8.2837**	-35.6258
	(2.1480)	(-0.7808)
Adj. R-squared	0.9927	0.9662
Sum sq. resids	4.1538	581.3857
S.E. equation	0.2826	3.3437
F-statistic	1914.6160	401.8141
Log likelihood	-6.2373	-147.0668
Akaike AIC	0.3942	5.3356
Schwarz SC	0.5735	5.5148
Mean dependent	103.0123	127.4171
S.D. dependent	3.3164	18.2009

Note: ***, **, and * are significant at 1, 5, and 10% respectively. Parentheses are t-statistic. From 2020.1 to 2024.3, policy interest rate was same.

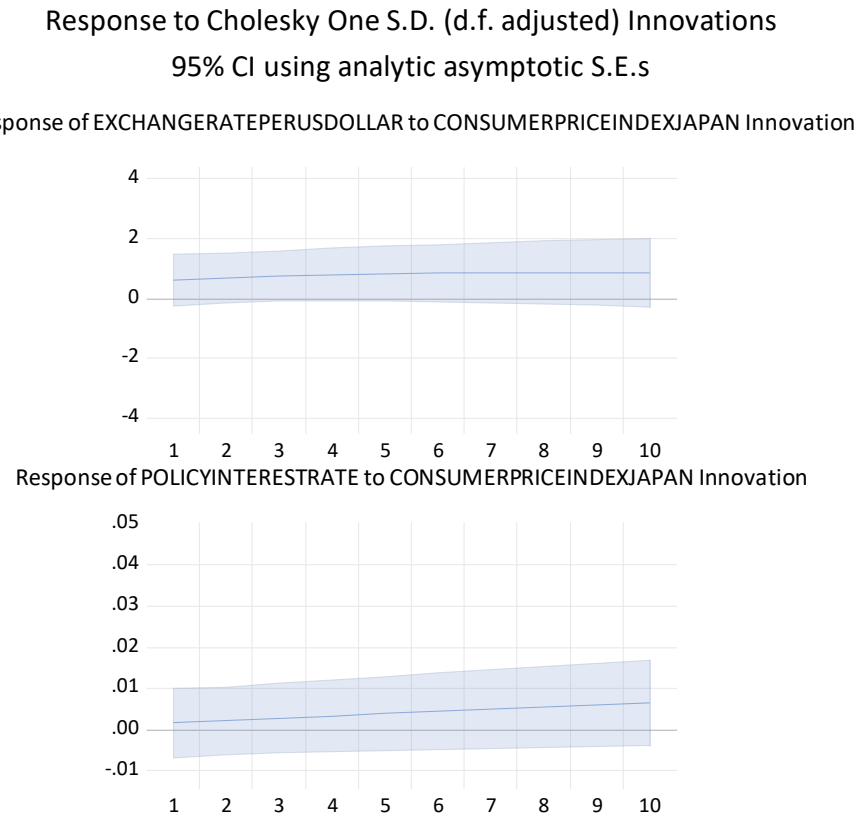

Figure 1: Impulse reaction

Most of the results are as expected. The exchange rate (with a one-month time lag) has significant influence on prices in Japan. Depreciation significantly impacts prices respectively. It is interesting to note that most of the coefficients of the policy interest rate are positive. There is a possibility that raising the policy interest rate may be seen as a 'positive sign' of the exit from deflation. Owing to the Impulse response, the effects persist for a long time. When implementing certain policies, this issue should be taken into account.

The regression results for equation (B) are shown in Table 5. The equations are (6) and (7). Both estimated equations yield expected results.

Table 5: Regression analyses

	(6)	(7)
Sample period	2020.1-2024.10	2020.1-2024.10
Method	Ordinary Least Squared	GMM
C	80.9233***	80.9064***
	(83.4242)	(66.3688)
Exchange rate(-1)	0.1743***	0.1751***
	(22.9988)	(16.2661)
Adjusted R-squared	0.9041	0.9033
S.E. of regression	1.0270	1.0311
Sum squared resid	58.0115	58.4846
Log likelihood	-81.3808	
F(J)-statistic	528.9473	4.5849
Prob(F(J)-statistic)	0.0000	0.0322
Akaike info criterion	2.9256	
Schwarz criterion	2.9973	
Hannan-Quinn criter.	2.9535	
Durbin-Watson stat	0.3120	0.3119

Note: ***, **, and * are significant at 1, 5, and 10% respectively. Instrumental variables are industrial production and policy interest rate for GMM. Parentheses are t-statistic. From 2020.1 to 2024.3, policy interest rate was same.

The results are robust, showing that the depreciation of the yen promotes inflation. The causality test between the exchange rate and prices is conducted and the results are shown in Table 6.

Table 6: Granger causality test

Null hypothesis	F-statistic	Prob.
Exchange rate does not cause Granger consumer price.	11.8062	0.0011
Consumer price does not cause Granger exchange rate.	0.07059	0.7915

The results are clear. The depreciation of the yen promotes inflation. No inverse relationship can be found.
Table 6 presents the results of the break point test. In Japan, by the middle of March 2024, a negative policy interest rate had been in effect. Also, from 2020 to May 2023, the monthly average exchange rate remained lower than 140yen per US dollar. After that, the yen depreciates sharply. The two points are used for estimation. The Null Hypothesis assumes no breaks at the specified breakpoints. The results are shown in Table 7.

Table 7: Chow Breakpoint test

F-statistic	17.89158
Prob.F	0.0000
Log likelihood ratio	50.20098
Wald Statistic	71.56631

The results are clear. Breaking points exist for both periods.

Finally, the effect of wage on inflation is examined. The results are presented in Table 8 and Table 9. The estimated equations are (8) and (9). The causality test is performed only on equation (8) due to limited sample size.

Table 8: Regression analyses

	(8)	(9)
Sample period	2020.1-2024.10	2023.4-2024.10
C	101.8077***	106.9482***
	(67.9016)	(94.0245)
Wage(-1)	0.0117	0.0015
	(0.8405)	(0.1489)
Adjusted R-squared	-0.0052	-0.0574
S.E. of regression	3.3251	1.4103
Sum squared resid	608.1103	33.8137
Log likelihood	-148.3477	-32.4359
F-statistic	0.7064	0.0221
Prob(F-statistic)	0.4042	0.8833
Akaike info criterion	5.2753	3.6248
Schwarz criterion	5.3470	3.7242
Hannan-Quinn criter.	5.3032	3.6416
Durbin-Watson stat	0.0298	0.0747

Note: ***, **, and * are significant at 1, 5, and 10% respectively.

Table 9: Granger causality test

Null hypothesis	F-statistic	Prob.
Wage does not cause Granger causality consumer price.	4.79034	0.0330
Consumer does not cause Granger causality wage.	0.35402	0.5543

The coefficients are positive as expected, but they are not significant. The results of the Granger causality test also have the expected signs, but equation (8) does not have the expected results.

Finally, the spread of the new coronavirus has had a major impact on Japan. In Japan, which has a high ratio of exports to imports, the supply shortages all over the world resulting from this pandemic led to inflation. The increase in policy interest rates to control inflation in various countries led to a relative decline in the value of the yen, which in turn boosted the earnings of large corporations and other large firms, increased external demand, and led to higher employment and wages, while at the same time causing import prices, including utility costs, to rise. A shortage of labor due to a shrinking population also contributed to higher wages and prices. Consumers eventually became more willing to accept higher prices, and firms began to pass the higher prices on to consumers.

5. Conclusion

This study has examined the deterministic elements of the recent price increases in Japan. Empirical analyses show that the depreciation of the yen led to higher prices in Japan, but no significant relationship was found between prices and the industrial production index, nor between prices and the policy interest rate. In addition, there was no evidence that wage increases caused price increases. Most of the results are expected and similar to other excellent studies on these topics. The results appear to be robust. However, the relationship between inflation and wages is not as clear as expected. One reason may be the lack of data, but there is some room for further study.

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