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Business cycle asymmetry: Evidence from Japan's decade-long deflation

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Abstract

This paper empirically examines the asymmetric behavior of macroeconomic time series under different economic regimes, focusing especially on whether the economy is in a deflationary or non-deflationary regime, using a threshold vector autoregression model (TVAR).

The results provide evidence in favor of asymmetric spillover effects from demand shocks on economic variables such as wages and consumption. In contrast to the non-deflationary period, during the deflationary period demand shocks are not clearly transmitted to the economy overall due mainly to the rigidity of nominal wages. The findings highlight that the state of the economy also matters when we consider the nature of the business cycle.

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Any views expressed herein are those of the author and not of the Cabinet Office. Any remaining errors are my own.

1. Introduction

Understanding the mechanisms underlying business cycles, one of the key concepts in macroeconomics, is important not only from an academic but also from a policy-making perspective in order to gauge the overall state of the economy and to devise effective economic policies. At the same time, however, these mechanisms may change depending on the state of the economy. In fact, it is well-known that business cycle characteristics– that is, the links between dynamics in the economy as a whole and individual macroeconomic time series–are nonlinear over phases of the business cycle, resulting in business cycle asymmetries.

Economic theory and empirical analysis suggest several conditions under which the nonlinear relationships between macroeconomic time series can explain the asymmetric nature of business cycles. One of the most prominent examples is nominal rigidity in prices and wages, a key feature of many macroeconomic models, which becomes more pronounced in periods of low inflation.

Given that Japan experienced decades of deflation, the question naturally arises whether this deflation has given rise to business cycle asymmetries – that is, whether propagation mechanisms differ in the deflationary and the non-deflationary regime. In other words, is there a change in dynamic links when the economy changes from an inflationary to a deflationary regime? This study empirically examines the asymmetric behavior of macroeconomic time series under different economic regimes, focusing especially on whether the economy is in a deflationary or non-deflationary regime, using a threshold vector autoregression (TVAR) model.

2. Asymmetric behavior of macroeconomic time series

Before exploring the TVAR model, the study starts by considering the dynamic cross-correlations obtained from a linear VAR model that assumes that both deflationary and non-deflationary periods are known in order to examine how the relationships among macroeconomic time series differed between the two periods, while identifying in which areas differences in business cycle characteristics can or cannot be observed. If the regime is known, the TVAR model reduces to an ordinary least squares (OLS) model for two distinct observation periods; in contrast, if the regime is unknown, it needs to be identified endogenously through the joint estimation of the optimal parameters using a Grid search (as will be done in the next section).

Data description and statistics

For the purpose of the analysis here, the study separates the observation period from

1980 to 2016 into deflationary and non-deflationary periods based on the official assessment of the Japanese government. Specifically, Japan experienced deflation from 1999Q4 to 2006Q2 and from 2009Q4 to 2013Q3, and for convenience these two periods together are referred to as the “deflationary period,” while the rest of the observation period is referred to as the “non-deflationary period.” Figure 1 shows the developments in Japan’s inflation rate, with the areas in grey depicting the deflationary period. During the deflationary period, prices fell by around 0.6 percent a year on average.

In order to examine differences in the relationships among macroeconomic time series under the different economic regimes, dynamic cross-correlation analysis examining up to six orders of cross-correlation of a series (x_t)with real GDP (gdp_{t+k}, where k represents the k quarter lag or lead of real GDP) is employed. The cross-correlation of each series with real GDP measures the strength of its correlation with real output (a proxy of the business cycle), and it is assumed that series $x_t$is procyclical if its cross-correlation is positive and countercyclicalif its cross-correlation is negative; moreover, series $x_t$is said to lag real GDP if its maximum correlation lags real GDP observations. Turning to the data used for the analysis, various quarterly macroeconomic time series spanning a wide range of fields, including consumption and investment, wages, deflators and prices, and financial market indicators, will be examined.

Differences in the relationships among macroeconomic time series

Table 1 shows the dynamic cross-correlations (with the 95percent confidence interval)in the deflationary period and the non-deflationary period to investigate the behavior of macroeconomic time series during each of the periods and compare them.

Looking at the direction and strength of the correlation, as well as whether a variable leads or lags the economy, particularly notable differences can be observed in relation to wages and prices:[1]

- Starting with wages, the correlation with output is lower in the deflationary than the non-deflationary period, particularly in the case of nominal wages.

[1]The business cycle characteristics in the non-deflationary period here are essentially in line with those reported in Urasawa (2018), which examined the stylized facts of Japanese business cycles. The stylized facts observed in Urasawa (2018) can be summarized as follows: Consumption and investment are contemporaneously procyclical, while the unemployment rate is countercyclical and strongly correlated with output; furthermore, it lags the economy. Employment is procyclical and lags fluctuations in output, reflecting the traditional pattern of labor input adjustment in Japan whereby in the early stages of an upswing or downswing, it is not the number of employees but hours worked that are adjusted. Wages and inflation are basically procyclical and lag fluctuations in output. Finally, stock prices are procyclical with a lead, while the effective exchange rate is counter-cyclical with a lag, that is, there is a negative correlation between an appreciation of the yen and output.

Specifically, the correlation coefficient for the wage index is 0.49 for the non-deflationary period but only 0.16 for the deflationary period (which is below the 95 percent confidence interval of the correlation coefficient obtained for the non-deflationary period). Similarly, the correlation coefficient for compensation of employees is 0.52 for the non-deflationary period but only 0.11 for the deflationary period. These results suggest that wages in the deflationary regime are more rigid than in the non-deflationary regime in the sense that they no longer relate to developments in the economy overall.

- Turning to prices, the correlation of inflation with output disappears in the deflationary period, which is consistent with the finding of a flattening in the slope of the Phillips curve during the deflationary period. Specifically, while the correlation coefficient for the GDP deflator is 0.24 for the non-deflationary period, it is –0.10 (below the 95 percent confidence interval of the correlation coefficient obtained for the non-deflationary period) for the deflationary period, while the corresponding values for the consumer price index are 0.46 and almost zero.

In sum, the results indicate a decreased responsiveness of wages and prices to economic activity, which points to differences in the propagation mechanisms in the economy in a deflationary and a non-deflationary regime. To further examine the reasons for these differences, the next section presents additional analyses based on a TVAR model, focusing on spillover effects on the demand side of the economy through wages and consumption (the consumption channel).[2]

3. Analysis of business cycle asymmetries using a TVAR model

To examine the business cycle asymmetries in more detail, this section presents the estimation of a TVAR model, which does not require any prior assumptions about different regimes. Since TVAR models, originally developed by Tong (1978) and Tsay (1998), allow the behavior of time series to depend on the state of the system, they provide a useful and flexible tool to capture possible non-linearities and asymmetric reactions to shocks.

Structure of the two-regime model

Consider the following TVAR (p) model with two regimes ($j = 1,2$) and a pth order lag, assuming that there is an observable threshold variable q_t, belonging to y, which is

[2] To examine the propagation mechanisms on the supply side of the economy through wages and the number of workers, the unemployment rate is used an alternative variable. However, no difference can be observed between two regimes.

a $(k \times 1)$ vector consisting of *k* observed variables:

$$y_t = \sum_{i=1}^{p} A_{j,i} y_{t-i} + \varepsilon_{t,j}$$

where $j = 1$ (deflationary regime) if $q_{t-d} < \gamma$ and $j = 2$ (non-deflationary regime) otherwise; γ is the value of the threshold; *d* is the lag of the threshold variable relevant for regime changes; $A_{j,i}$ is the matrix of coefficients of regime *j* and lag *i*. Each regime can be characterized by a variance-covariance matrix $\sum_j$.

Note that the model is linear within each regime, while changes in the parameters across regimes account for non-linearities. The TVAR model can be estimated using OLS conditional on the threshold variable, q_{t-d}, the number of regimes, and the order *p*. Given the linearity of the model within each regime, using conditional least squares (for all possible threshold values) under the assumption of a given number of regimes, the model is estimated by minimizing the sum of squares of the residuals.

Data and settings

The TVAR model used in this study is based on four time series consisting of real GDP (GDP), nominal wages (NWG), nominal private consumption (NPC), and the consumer price index (CPI).[3] For the estimation, data from 1980Q1 to 2016Q3 is employed using log differences. Structural shocks are identified through are cursive approach assuming that the time ordering of variables is GDP, NWG, NPC, and CPI. In the estimation, the threshold variable is assumed to be the first lag of CPI, and the threshold γ is assumed to be an unknown parameter.

Employing this approach, the differences in propagation mechanisms between the deflationary and the non-deflationary regime are examined, focusing on nominal rigidity. Specifically, how the response of wages, consumption, and the CPI to a structural shock in GDP (demand shock) differs between the two regimes is examined. The model allows two ways in which the propagation of structural shocks can differ; that is, in the way that shocks are propagated contemporaneously via differences in the covariance matrices for disturbances, and in the way they are propagated dynamically via differences in lag polynomials.

Estimation results

Figure 2 shows the estimation results of the TVAR model and a linear VAR model of

[3]To avoid an implausible number of regime switches over time, the average of four subsequent quarters of the series in log differences is used.

the cumulative impulse responses of GDP, NWG, NCP, and CPI to a structural shock to each of these variables. For the TVAR model, the figure shows the cumulative impulse responses in both the deflationary regime, defined as periods with an inflation rate below the threshold value of 0.06, and the non-deflationary regime, defined as periods with inflation above the threshold value. For the linear VAR model, the results for the entire period (1980Q1 to 2016Q3) are shown.

The estimation results suggest the following. The initial response of GDP to a demand shock (structural shock to GDP)differs substantially between the two regimes, with the simultaneous correlation of a demand shock dropping from 1.2 in the non-deflationary regime to 0.7 in the deflationary regime. In addition, subsequent responses are also weaker, resulting in flatter impulse responses in the deflationary regime (below the 95 percent confidence interval obtained from the linear VAR model); in contrast, in the non-deflationary period, impulse responses display a strong and persistent reaction of output to a demand shock.

This is also true for the responses of NWG, NCP, and CPI to a demand shock, indicating a weaker response to economic activity in the deflationary regime, which is consistent with the result in the previous section that the correlation between output and both wages and prices was substantially lower in the deflationary period.

A likely reason for the weaker response of consumption and prices is the weaker response of wages; in contrast, the responses of NCP and CPI to own shocks are the same in the two regimes (within the 95 percent confidence interval obtained from the linear VAR model).This implies that nominal wages appear to be downwardly and even upwardly rigid in the deflationary regime, so that they do not respond to demand shocks, resulting in weaker spillover effects on the economy through the consumption channel.

4. Conclusion

Aggregate output, as measured by real GDP, fluctuates as a result of various shocks to the economy as well as the way that such shocks are transmitted to the economy. Although business cycle characteristics to some extent can be regarded as universal and constant over time, they can change depending on the state of the economy. Against this background, this study estimated a TVAR model to quantify the differences in propagation mechanisms in the Japanese economy in a deflationary and a non-deflationary regime, providing evidence in favor of asymmetric spillover effects from demand shocks on economic variables such as wages and consumption.

References

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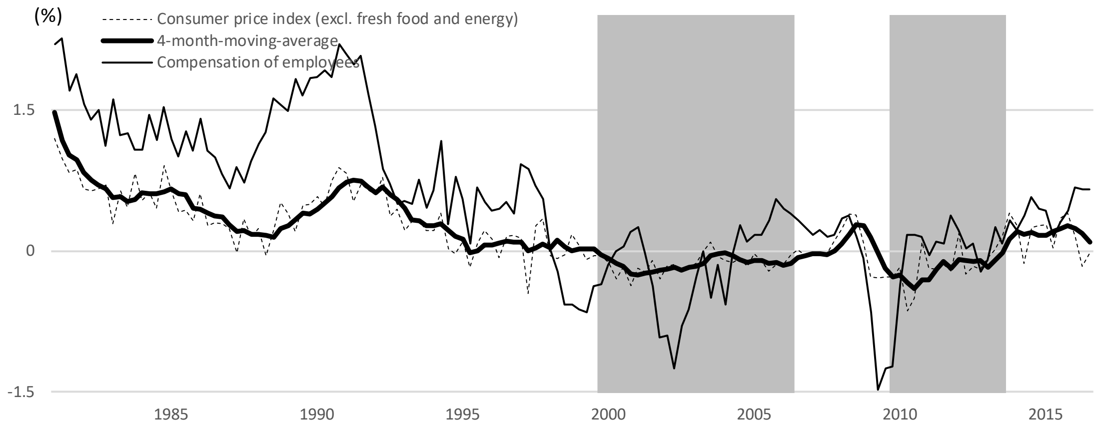
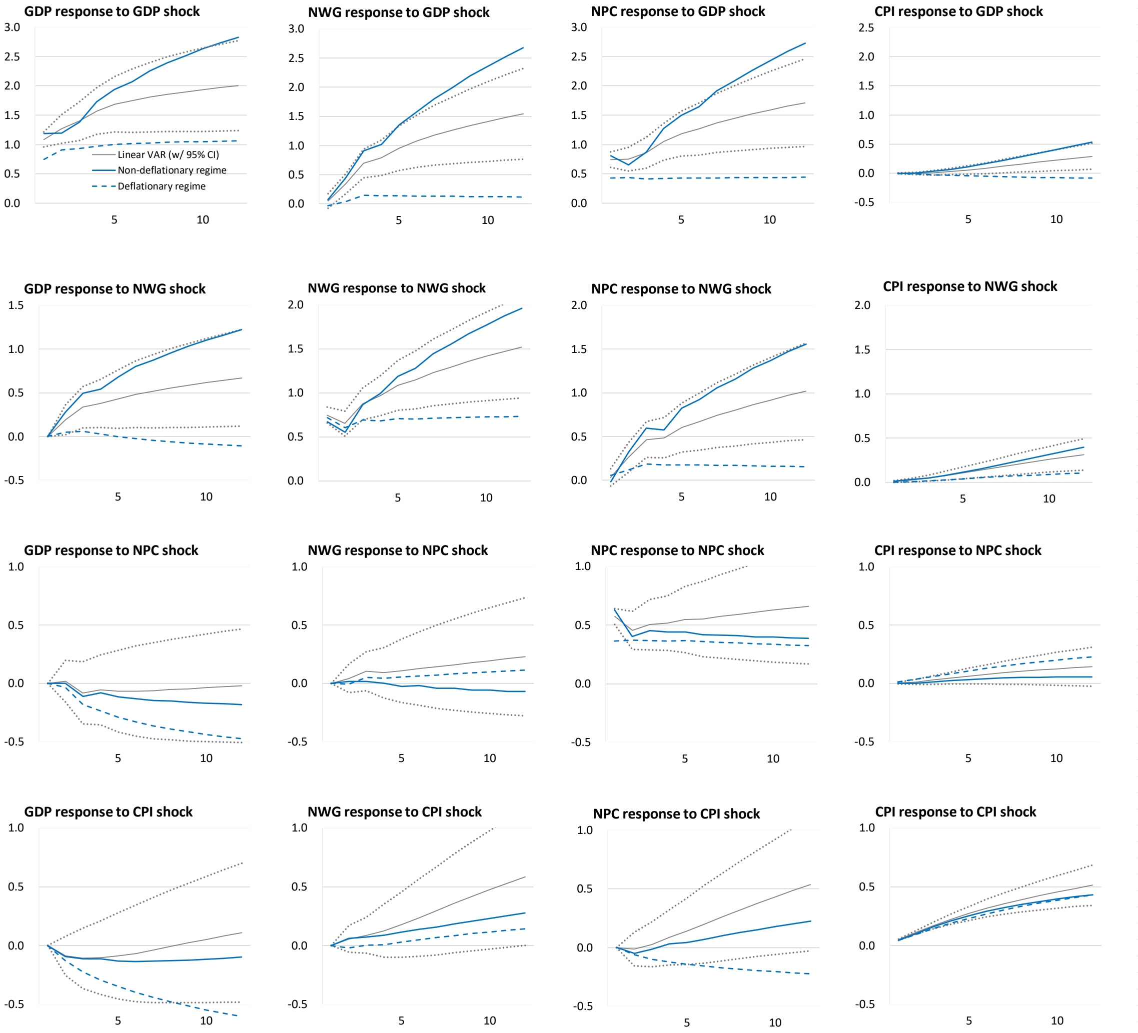
Figure 1: Developments in Japan's inflation rate and wage growth



Notes: The thick solid line shows the 4-month-moving-average of the log difference of the CPI, while the broken line shows the log difference of the CPI. The CPI figures exclude the direct effects of the consumption tax hikes in1989, 1997, and 2014. The thin solid line shows the 4-month-moving-average of the log difference of the Compensation of employees. Shaded areas represent deflationary periods as identified by the Cabinet Office.

Figure 2: Impulse responses of GDP, wages, consumption, and CPI to a shock to each of these variables: TVAR model and linear VAR model



Notes: The panels show the cumulative impulse responses obtained with the TVAR model for the deflationary period (thick broken line) and the non-deflationary period (thick solid line), together with the results of the linear VAR model (thin line) with the 95 percent confidence interval (indicated by the thin broken lines).

Table 1: Dynamic cross-correlations: deflationary and non-deflationary period

Macroeconomic time series	Deflationary period: Maximum correlation with GDP (Corr[xt, gdpt+k])	95% C.I.		lag k<0 / k=0 / lead k>0	Non-deflationary period: Maximum correlation with GDP (Corr[xt, gdpt+k]	95% C.I.		lag k<0 / k=0 / lead k>0
GDP components (real) and employment								
Private consumption	**0.74**	0.62	0.86	k=0	**0.71**	0.63	0.80	k=0
Private residential investment	**0.12**	-0.17	0.40	k=0	**0.23**	0.06	0.41	k=0
Private non-resid. investment	**0.26**	0.18	0.34	k=1	**0.56**	0.42	0.69	k=0
Government consumption	**0.10**	-0.20	0.41	k=0	**0.22**	0.04	0.41	k=0
Public investment	**0.15**	-0.11	0.41	k=0	**0.14**	-0.06	0.33	k=0
Exports	**0.66**	0.49	0.83	k=0	**0.50**	0.36	0.65	k=0
Imports	**0.48**	0.37	0.59	k=-1	**0.36**	0.20	0.52	k=0
Employees	**0.36**	0.25	0.47	k=-1	**0.41**	0.34	0.47	k=-2
Average hours worked (total)	**0.44**	0.34	0.54	k=0	**0.26**	0.10	0.41	k=0
Unemployment rate	**-0.43**	-0.55	-0.31	k=2	**-0.46**	-0.54	-0.38	k=-1
Effective job-openings-to-applicants ratio	**0.46**	0.34	0.59	k=-1	**0.53**	0.46	0.60	k=-1
Labor productivity	**0.95**	0.92	0.98	k=0	**0.96**	0.95	0.97	k=0
Wages								
Wage index (total cash earnings, nominal)	**0.16**	0.07	0.24	k=-1	**0.49**	0.43	0.55	k=-1
Wage index (total cash earnings, real)	**0.24**	0.15	0.34	k=1	**0.33**	0.25	0.41	k=-1
Compensation of employees (nominal)	**0.11**	0.03	0.19	k=1	**0.52**	0.48	0.57	k=-1
Labor share	**-0.73**	-0.87	-0.60	k=0	**-0.69**	-0.76	-0.63	k=0
Deflators and prices								
GDP deflator	**-0.10**	-0.18	-0.03	k=1	**0.24**	0.19	0.29	k=-1
Consumer price index	**0.07**	0.00	0.13	k=-1	**0.46**	0.39	0.53	k=-2
CPI (excl. fresh food)	**-0.08**	-0.38	0.23	k=0	**0.44**	0.37	0.50	k=-2
CPI (excl. fresh food and energy)	**-0.09**	-0.17	-0.01	k=1	**0.30**	0.21	0.40	k=-1
Interest rates and stock prices								
Call rate (collateralized overnight)	**-0.26**	-0.34	-0.18	k=3	**0.29**	0.22	0.35	k=-1
Newly issued government bonds (10-year)	**0.16**	0.09	0.23	k=2	**0.42**	0.34	0.49	k=-1
Stock prices	**0.13**	-0.18	0.44	k=0	**0.28**	0.23	0.34	k=1
Money and exchange rate								
Money stock (M2, nominal)	**-0.07**	-0.37	0.24	k=0	**0.47**	0.39	0.54	k=1
Monetary base (nominal)	**-0.21**	-0.31	-0.10	k=-1	**-0.08**	-0.27	0.11	k=0
Effective exchange rate	**0.17**	0.09	0.25	k=-1	**-0.21**	-0.40	-0.03	k=0

Notes: The table reports the maximum value of six orders of cross-correlation of each series with real GDP in the deflationary period and the non-deflationary period with the 95percent confidence interval.