



Bank of Japan Working Paper Series

Nonlinear Input Cost Pass-through to Consumer Prices: A Threshold Approach

Takatoshi Sasaki*

takatoshi.sasaki@boj.or.jp

Hiroki Yamamoto*

hiroki.yamamoto@boj.or.jp

Jouchi Nakajima**

nakajima-j@ier.hit-u.ac.jp

No.23-E-9
May 2023

Bank of Japan
2-1-1 Nihonbashi-Hongokuchō, Chūō-ku, Tokyo 103-0021, Japan

* Monetary Affairs Department

** Institute of Economic Research, Hitotsubashi University and Monetary Affairs Department, Bank of Japan

Papers in the Bank of Japan Working Paper Series are circulated in order to stimulate discussion and comments. Views expressed are those of authors and do not necessarily reflect those of the Bank.

If you have any comment or question on the working paper series, please contact the authors.

When making a copy or reproduction of the content for commercial purposes, please contact the Public Relations Department (post.pr8@boj.or.jp) at the Bank in advance to request permission. When making a copy or reproduction, the source, Bank of Japan Working Paper Series, should explicitly be credited.

Nonlinear Input Cost Pass-through to Consumer Prices: A Threshold Approach^{*}

Takatoshi Sasaki[†] Hiroki Yamamoto[‡] Jouchi Nakajima[§]

May 2023

Abstract

This paper examines a possible nonlinearity in the pass-through to CPI inflation of increases in firms' input costs. Using Japanese data, the paper empirically investigates whether the degree of the pass-through rises when increases in costs exceed a certain threshold. Three main empirical results are obtained. First, there is a statistically significant nonlinearity in that the pass-through to CPI inflation of increases in producer prices, exchange rates, and wages rises once the increase in each of these variables exceeds a certain threshold. Second, our nonlinear model is superior to the linear model used in previous studies in terms of in-sample model fit and out-of-sample forecasting performance, suggesting that the linear model underestimates the degree of the pass-through of an input-cost increase that exceeds the threshold while overestimating that of a smaller input-cost increase. Third, the estimated impact of the nonlinear pass-through of increases in producer prices and exchange rates on CPI inflation is often transitory, whereas that of wage growth tends to be persistent due to the observed higher inertia in wage growth. These results suggest that whether a nonlinearity will arise in the pass-through of wage growth is one of the most important issues for future developments in CPI inflation.

JEL classification: C24, E31, E58

Keywords: Inflation, Pass-through, Nonlinearity, Threshold model

^{*} The authors are grateful to Luigi Donayre, Toyochiro Shirota, Benjamin Wong, seminar participants at the 30th SNDE Annual Symposium, and staff members of the Bank of Japan for their valuable comments and discussions. The authors also thank Atsuki Hirata for excellent research assistance. All remaining errors are attributable to the authors. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Japan.

[†] Monetary Affairs Department, Bank of Japan (E-mail: takatoshi.sasaki@boj.or.jp)

[‡] Monetary Affairs Department, Bank of Japan (E-mail: hiroki.yamamoto@boj.or.jp)

[§] Institute of Economic Research, Hitotsubashi University (E-mail: nakajima-j@ier.hit-u.ac.jp) and Monetary Affairs Department, Bank of Japan

1. Introduction

In 2022, against the backdrop of several factors such as the surge in global commodity prices and the depreciation of the yen, firms in Japan faced a rapid and large increase in their input costs and many of them ended up raising their selling prices. As a consequence, the year-on-year inflation rate of the consumer price index (CPI) reached as high as that in the early 1980s and recorded the highest level of CPI inflation in around four decades, as can be seen in Panel 1. There have been a number of studies examining the relationship between firms' input costs, such as crude oil prices and exchange rates, and the CPI, many of which assume in their empirical analysis a linear relation between changes in these costs and CPI inflation (see for example, Campa and Goldberg, 2005). However, the recent price-setting behavior of firms suggests a possible nonlinearity in the impact (i.e., pass-through) of the cost increases to CPI inflation, such that the degree of pass-through depends on the magnitude of increases in the input costs. For instance, we may consider that firms keep their selling prices unchanged as long as an increase in their input costs is less than a certain threshold; once the increase is more than the threshold, the firms end up raising the prices. In this case, the degree of the pass-through of the increase in input costs to CPI inflation rises once the increase exceeds the threshold.

The possibility of nonlinearity in the pass-through to inflation suggests that linear models used in previous studies could underestimate the degree of the cost pass-through to inflation for periods when the cost variables increase rapidly and markedly. Against the backdrop of the recent high inflation across the globe, the nonlinear dynamics of inflation have attracted attention from both academics and policymakers as one of the most important issues from the perspective of monetary policy conduct (Taylor, 2000; BIS, 2022; Borio et al., 2023; Gopinath, 2023).

A growing body of literature on the nonlinear pass-through has used so-called threshold models.¹ For example, Colavecchio and Rubene (2020) develop a regression model in which the degree of the exchange-rate pass-through to inflation rises when changes in the exchange rate exceed a threshold. Their study sets the threshold equal to one standard deviation of changes in the exchange rate during the estimation sample period and finds nonlinearity in the exchange-rate pass-through in the euro area. Caselli and Roitman (2019) report that the degree of the exchange-rate pass-through to inflation for emerging market

¹ In addition to those with threshold models, there have been empirical studies on the nonlinearity of pass-through that use time series models with regime switching. See, for example, Shintani et al. (2013), who use a smooth transition model in which the values of model parameters evolve gradually with regime switching, and show that the degree of the exchange-rate pass-through to inflation depends on the past inflation rate in the U.S.

economies increases when changes in the exchange rate exceed the threshold. Likewise, Ben Cheikh et al. (2018) point out that the degree of the exchange-rate pass-through increases during periods of economic expansion in the euro area. As for Japan, Yagi et al. (2022) show that the pass-through of changes in raw material costs and exchange rates tends to rise during periods of high volatility in upstream costs and exchange rates, as well as in periods of economic expansion.

Many previous studies estimate the degree of the nonlinear pass-through for only one cost variable. However, we can consider the possibility of nonlinear pass-through for each of multiple cost variables. If the pass-through is indeed nonlinear for some of them, the econometric approach employed in the previous studies leads to a biased estimate. Moreover, most of the previous studies choose a fixed value for the threshold of the cost variable. For example, Colavecchio and Rubene (2020) set the threshold for changes in the exchange rate to be one standard deviation of the changes during the estimation sample period. However, the existence and levels of thresholds are unknown a priori.

This paper develops a threshold model for the nonlinear pass-through of multiple cost variables in order to estimate correctly the degree of the nonlinear pass-through to inflation and proposes an econometric approach to estimate the degree of the pass-through, including thresholds for multiple cost variables. We then investigate whether a nonlinearity is present in the pass-through of cost variables (i.e., producer prices, exchange rates, and wages) to CPI inflation, using Japanese data.

Our main empirical results are threefold. First, there is a statistically significant nonlinearity in the pass-through of increases in producer prices, exchanges rates, and wages to CPI inflation. The degree of the pass-through rises significantly once the cost increases exceed their respective estimated thresholds. This implies that a rapid and large cost increase could push inflation up in a nonlinear manner through not only the large size of the cost increase itself but also the associated increase in the degree of its pass-through.

Second, our nonlinear model is superior to the linear model used in previous studies in terms of in-sample model fit and out-of-sample forecasting performance. The linear model underestimates the pass-through of an input-cost increase that exceeds the threshold while overestimating that of a smaller input-cost increase. Moreover, using a linear model to forecast inflation could underestimate the future path of inflation in the face of a rapid and large increase in input costs.

Third, the historical decomposition of the year-on-year CPI inflation rate based on our estimated nonlinear model shows that the estimated impact of nonlinear pass-through of increases in producer prices and exchange rates on inflation is often transitory, while that of

wage growth tends to be persistent due to the observed higher inertia in wage growth. This empirical result suggests that if wage growth increases in the future, the nonlinear pass-through of wage growth will be one of the most important issues for future developments in CPI inflation after the nonlinear pass-through of producer prices and exchange rates emerged in 2022.

The remainder of the paper is organized as follows. Section 2 describes our econometric approach and data for the nonlinear pass-through. Section 3 presents the empirical results of the nonlinear input-cost pass-through to CPI inflation. Section 4 concludes.

2. Econometric approach and data

This section explains the formulation of our approach to specifying the nonlinear pass-through. Panel 2 shows an illustration of our threshold model. A standard linear model assumes that the degree of the pass-through is constant, not depending on the magnitude of increases in a cost variable. By contrast, following previous studies such as Colavecchio and Rubene (2020) among others, our nonlinear model addresses the possibility that the degree of the pass-through rises once the increase in the cost variable exceeds its threshold as the cost-push pressure to inflation is kinked upward above the threshold. Our baseline model assumes that the nonlinearity of the pass-through emerges only for increases in cost variables. As a part of robustness checks, we consider both nonlinearities for increases and decreases in cost variables, setting not only an upper threshold but also a lower threshold below which the pass-through can vary in a nonlinear manner.

2-1. Econometric model

We consider the following threshold regression model:

$$y_t = c + \sum_{i=1}^k \beta_i \cdot x_{i,t-h} + \sum_{i=1}^k \gamma_i \cdot (x_{i,t-h} \cdot I[x_{i,t-h} > d_i \sigma_i]) + \varepsilon_t \quad (1)$$

where y_t is the year-on-year change in the CPI as the dependent variable. The explanatory variables $x_{i,t-h}$ are the year-on-year growth rates of firms' input costs and the level of economic slack in the economy.² $I[\cdot]$ is the indicator function that takes a value of 1 if the condition specified in the brackets $[\cdot]$ is satisfied, otherwise a value of 0. σ_i is the standard

² When we run the regression, we standardize each explanatory variable by the mean and variance within the sample period. The coefficients excluding the constant term are re-scaled to the variation before standardization in the estimation result in Section 3.