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Abstract

Concentrating on the period of quantitative easing in Japan, this paper reexamines the correlation between the asymmetry of sectoral relative-price changes and the aggregate inflation rate. This correlation is widely interpreted as evidence that short-run inflation is determined by supply-side factors; however, we study whether, in addition to the inflation rate, monetary environment and aggregate demand explain this correlation. Using producer price index data, we show, first, that the positive and significant effect of relative-price change asymmetries on inflation is not robust with respect to various indicators of asymmetry. Second, indicators of aggregate demand and monetary environment affect the measures of asymmetries, which raises doubt about whether they can be interpreted as pure supply-side indicators. Third, in addition to the indirect effect via measures of asymmetries, demand and monetary factors directly affect inflation. Thus, we reject the claim that the recent disinflation/deflation period can be understood as primarily a supply-side phenomenon.

I. Introduction

Japan has been in a long period of disinflation and deflation. As shown in Figure 1, the rate of aggregate price change based on the consumer price index declined during most of the Heisei recession (1990–2003), except during a short period around 1997–1998. Moreover, pure deflation was the norm after 1999 until late 2007, except for a few hikes above zero. Although the rate then became positive through 2008, more recently it has again turned negative. Such a long period of disinflation/deflation, lasting almost 20 years, is a rarity in history.[1] It is no surprise, therefore, that a serious debate has arisen over the causes and remedies. Although researchers point to various causes, the debate can be basically characterised as one over supply- versus demand-side factors. Some argue that this disinflation/deflation is mainly a supply-side phenomenon, as it was caused by such factors as lower energy prices or the influx of inexpensive imports. Others maintain that a lack of demand due to the weak economy is the main culprit. If the latter viewpoint is more correct, government action to mitigate the situation is possible, whereas the scope of such action is limited if the former view is more likely. This debate, vehement during the recession, seems to be growing even more lively as concerns for a 'deflation spiral' loom over the economy. Of particular interest is the subperiod from March 2003 to March 2006, which was characterised by the monetary policy approach of quantitative easing.

An academic discourse in economic theory runs parallel to this debate. Although there is a consensus that growth in the money supply is the main determinant of inflation in the long run, theorists disagree on the determinants of inflation in the short run.[2] This debate is also heavily influenced by the question of whether supply-side or demand-side factors are primarily responsible for movements in prices. Traditional Keynesians emphasise the importance of fiscal policy and aggregate demand; new classical economists stress the importance of supply-side factors; and monetarists note the relevance of an inappropriately conducted monetary policy in addition to the supply side. New Keynesian approaches no longer discount the potential importance of supply-side factors; rigidities are no longer assumed *a priori*, but are explained within a framework of microeconomic optimisation behaviour.

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[1] Another notable example of a long disinflation period occurred in the United States from 1979 to the mid 1980s. However, this phase lasted for only about six years and the inflation rate never went below zero.
[2] As deflation is negative inflation, the term 'inflation' will be used hereafter to mean both an increase and a decrease of the general price level.

Figure 1: CPI inflation rate for Japan (1999.01-2009.12)
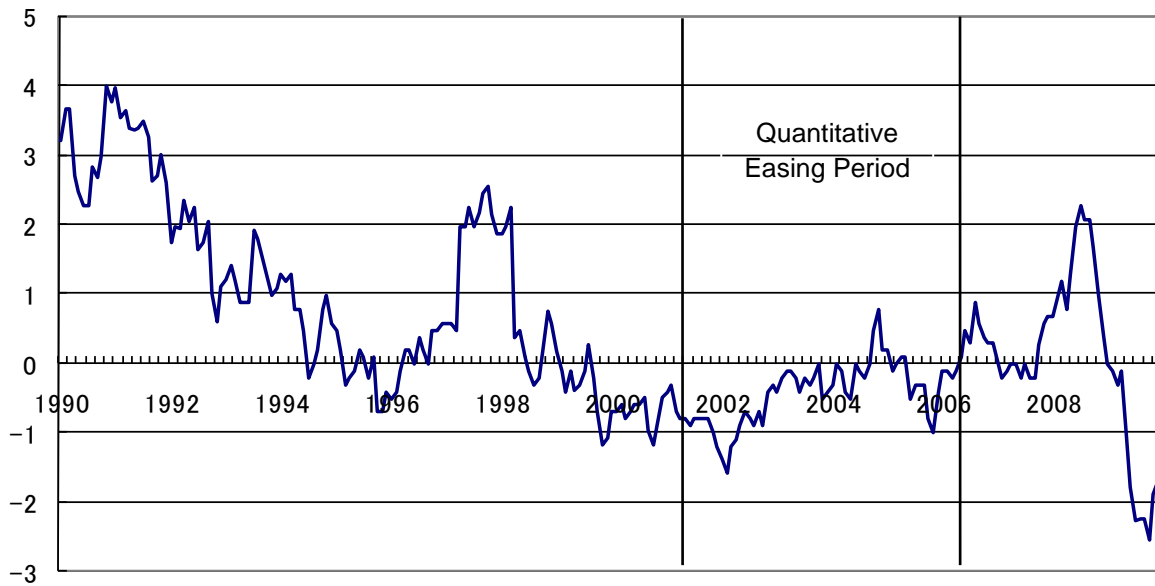
Source: Bank of Japan.

Of particular relevance in the context of explaining short-run inflation is a theory put forward by Ball and Mankiw (1995), which has attracted much attention since its publication. Assuming imperfect competition due to menu cost pricing and monopolistic competition, they show that large, but not small, positive (negative) sectoral shocks skew the distribution of relative-price changes across sectors to the right (left) and push up (down) the mean of the updated prices simultaneously. Empirically, this implies a positive correlation between the skewness of the distribution of relative-price changes and the rate of change of the aggregate price level. The authors provide empirical evidence for their theory using data on the United States.

Following Ball and Mankiw (1995), several papers investigate the validity of this hypothesis for various countries (see, e.g., Amano and Macklem (1997) for Canada; Demery and Duck (2008) for the United States; Dopke and Pierdzioch (2003) for Germany; Mendez-Carbajo and Thomakos (2004) for Spain). However, there are only a few studies that test this theory for Japan. Using monthly data on the consumer price index, Watanabe et al. (2003) detect a positive correlation between the inflation rate and asymmetry in relative-price changes over the period 1971–2002. Gerlach and Kugler (2007) confirm that finding for the period 1981–1986 using the method of a random cross-section sample split to address the small sample issue pointed out by Bryan and Cecchetti (1999). Finally, Holly (1997) controls for the growth

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in money and rejects the Ball and Mankiw (1995) hypothesis, based on Japanese wholesale price data for 1976–1994.

Presumably because Ball and Mankiw (1995) themselves present it as chiefly a supply-side theory, many people associate the success of this theory with that of the supply-side theory of short-run inflation. For instance, Ball and Mankiw (1995, 169) note, referring to a sectoral shock, that 'one can interpret the shock as a shift in the industry demand or cost function', but only mention a monetary shock as one such demand factor, without incorporating it into their regressions. Watanabe et al. (2003, 220) state that they measure the supply shock by examining how the distribution is skewed to the left and allude that the detected positive correlation may be a reflection of international transfers of technology and influx of inexpensive imports from China. Demery and Duck (2008) claim that the failure to detect such a correlation in their estimations is evidence against the supply-side explanation of inflation, referring to Fischer's (1981) comment on the positive correlation between the first and *second* moments of the relative-price changes.

Gerlach and Kugler (2007) assume from the start of their analyses that skewness reflects pure supply-side effects. Watanabe et al. (2003) approach the issue a little more cautiously; they observe the time profile of their asymmetry indicator over the business cycle. Noting that it is not pro-cyclical, they conclude that the asymmetry is indeed a supply shock. They also include the output gap as well as change in money supply in their regressions. They then show the asymmetry survives multicollinearity, i.e.*,* it still holds positive and significant. Further, they argue that the asymmetry indicator may be endogenous, as it could be affected by demand shocks, and show in an instrumental variable regression that this is not the case. Although such evidence lends some support to the interpretation, these analyses do not directly address the issue and thus do not preclude the possibility that the demand factor is reflected in the asymmetry.

However, we investigate explicitly the hypothesis that demand-side factors can also cause skewness in the distribution of sectoral relative-price changes. For instance, if a monetary policy shock influences demand in different sectors differently, then the distribution of sectoral relative-price changes is affected by the demand side.[3] More generally, any rise in aggregate demand that causes sector-specific changes may also generate sectoral relative-price changes, resulting in a skewed distribution. Therefore, the positive correlation between skewness and inflation can be due to both supply-side and demand-side factors.

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[3] There is considerable empirical evidence for such asymmetric effects of monetary policy (Hayo and Uhlenbrock 2000; Dedola and Lippi 2005; Peersman and Smets 2005).

The purpose of this paper is to examine whether 'monetary policy and other determinants of aggregate demand have important roles' (Ball and Mankiw 1995, 161) in explaining the short-run behaviour of inflation in the context of the recent Japanese episode of disinflation/deflation. In other words, we question the association of the positive asymmetry-inflation correlation with the supply-side hypothesis. To focus on this hitherto neglected aspect of the demand-supply debate, we choose the recent economic situation of Japan. First, to derive a consistent and identifiable indicator of monetary conditions in Japan, we concentrate on the period of quantitative easing as conducted by the Bank of Japan from March 2001 to March 2006. During this time, widely used indicators, such as short-term interest rates or changes in the money supply, do not work. Instead, we construct an indicator based on commercial banks' excess reserve at the Bank of Japan. Second, we directly examine the relationship between the measured asymmetry of sectoral relative-price changes, on the one hand, and the monetary policy and a measure of aggregate demand, on the other. Third, to get a better grasp of the dynamic nature of the effects, we employ impulse response analysis in addition to simple time-series regressions.

The paper is organised as follows. The next section derives various indicators of relative price-change asymmetries and then reexamines, using a battery of such indicators, whether these asymmetries affect inflation. Section III studies whether the demand-side factors and the monetary environment affect the various measures of relative-price change asymmetries, i.e., whether demand side and monetary environment affect inflation indirectly through asymmetries. Section IV investigates whether price asymmetries play a noteworthy role in explaining short-run inflation after including the direct effect of demand side and monetary environment. Section V studies the dynamic impact of supply, demand, and monetary shocks on inflation by examining impulse responses based on vector autoregressive (VAR) models. The final section concludes the paper with a summary, caveats, and suggestions for future research.

II. Reexamination of the Impact of Asymmetric Relative Price Changes

As a first step, we reexamine, with data on Japan for the period of quantitative easing, whether price asymmetries affect inflation, as found by Watanabe et al. (2003). From the various price series available, we follow Ball and Mankiw (1995) in choosing producer prices[4]. This indicator is more appropriate than consumer prices in respect to the underlying hypothesis regarding the price setting of firms and is not subject to the typical price-

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[4] Corporate Goods Price Index, see http://www.boj.or.jp/en/theme/research/stat/pi/cgpi/index.htm.

smoothing behaviour of retail companies, which is mainly responsible for the relatively lower variation of consumer prices.

Ball and Mankiw (1995) suggest various alternative indicators for measuring the asymmetries of relative-price change. Apart from skewness (the third moment) of the underlying price data, they look at:

$$AsymX = \int_{-\infty}^{-x} rh(r)dr + \int_{x}^{\infty} rh(r)dr \tag{1}$$

where: r: industry relative-price change (industry inflation rate minus the mean of industry inflation rates),

h(r): density of r, including the weighing for industry size.

Relative-price changes greater than X and smaller than –X define the tails of the distribution. We employ cut-off points at X = 10 and X = 5, which yield variables Asym10 and Asym5. These capture relative price changes greater than 10% or 5%, respectively. A third indicator, AsymQ, does not assume a specific cut-off point but lets the weights on the relative price changes increase linearly with the size of the adjustments:

$$AsymQ = \int_{-\infty}^{\infty} |r| rh(r)dr \tag{2}$$

These three indicators are zero for symmetric distributions. Increases in the variance magnify the tails of the distribution and raise the value of the indicator. In the case of positive values of Asym, the right tail of the distribution is larger than the left tail and vice versa.

Watanabe et al. (2003) argue that the Asym indicators are suboptimal, as they could lead to a 'spurious' correlation with inflation if the latter is positively correlated with the standard deviation of prices. They propose, instead, a class of alternative indicators that are immune to this problem.

$$SX = \sum_{i \in I_L \cup I_R} \omega_i v_i \tag{3}$$

where: v_i: relative price change of the ith item,

ω_i: weight thereof (value of ith item relative to total value of all commodities)

$I_L \equiv \{j \mid v_i \in (-\infty, L]\}$,

$I_R \equiv \{j \mid v_i \in [R, -\infty)\}$,

and L is chosen such that the sum of all ω_i with the corresponding v_i satisfying $\{v_i \in (-\infty, L]\}$ is X (e.g., if X = 15, items are picked up in ascending order until the sum of their weights

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becomes 0.15). R is chosen similarly. Given that in our dataset there is indeed a positive correlation between inflation and the standard deviation, albeit relatively weak (correlation coefficient of 0.19), we also compute asymmetry indicators for $X = 15$ and $X = 5$, called S15 and S5, respectively.

Table 1 provides correlation coefficients for the various indicators of asymmetries in relative-price changes.[5] All correlations between the indicators are positive, but their strengths vary considerably. Thus, we feel confident that we have computed a range of related but still different indicators for price asymmetries, which should provide a sound basis for drawing robust conclusions.

Table 1: Correlations Matrix Between Skewness and Alternative Indicators of Price Asymmetry

	ASYM5	ASYM10	ASYMQ	S5	S15
SKEW	0.57	0.62	0.75	0.73	0.66
ASYM5	1	0.42	0.84	0.82	0.69
ASYM10		1	0.66	0.41	0.36
ASYMQ			1	0.92	0.88
S5				1	0.94
S15					1

Employing these various indicators, we examine whether the result of Ball and Mankiw (1995) holds in our sample of monthly data. Table 2 contains the outcome of OLS regressions of producer price inflation on the various indicators of asymmetric shocks. We include the standard deviation of relative-price changes as a control variable. The coefficient of determination is very high, but this is mainly due to the lagged inflation variable. Although the coefficient is close to unity, Japanese inflation over this time period does not appear to experience stochastic nonstationarity. Both the Dickey-Fuller test with a constant and a deterministic trend (H_0: nonstationarity) and the Kwiatkowski et al. test (H_0: stationarity) indicate a stationary series at the 5% level.

Our results are only partially in accordance with the Japanese evidence presented in Watanabe et al. (2003) and Gerlach and Kugler (2007). In the basic model (1) of Table 2, only the standard deviation of relative-price changes has a significantly positive impact on

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[5] All indicators are based on the corporate goods price index (see footnote 7). The construction of these indicators follows equations (1) through (3). SKEW is the estimate of the distribution's third moment.

inflation, whereas skewness is insignificant. In model (2), following Ball and Mankiw (1995), we add the interaction of standard deviation and skewness. In contrast to their findings, in our setting it is not significant, neither using robust standard errors nor using normal standard errors. The standard deviation remains significant. For the alternative indicators of asymmetric price shocks based on Ball and Mankiw (1995) in models (3), (4), and (5), we do not find significant results. However, the asymmetry indicators S5 and S15 based on Watanabe et al. (2003) in models (6) and (7) fare much better. They are individually significant at the 5% and 10% levels, respectively, and the standard deviation is now less significant than before. Thus, for some indicators, we find that asymmetric price shocks affect the inflation rate in Japan during the period of quantitative easing; for others, we do not.

Table 2: Explaining Inflation by Price Asymmetry Indicators

$$\text{Inflation}_t = \hat{\alpha} + \hat{\beta}_1 \text{Inflation}_{t-1} + \hat{\beta}_2 \text{Standard Deviation}_t + \hat{\beta}_3 \text{Asymmetry Indicator}_t + \varepsilon_t$$

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.003*	-0.003*	-0.002*	-0.003**	-0.002(*)	-0.002(*)	-0.002
Lagged inflation	0.996**	0.995**	1.002**	1.002**	0.996**	0.991**	0.982**
Standard deviation	0.254**	0.268*	0.250*	0.273**	0.215*	0.210(*)	0.189(*)
Skewness	0.0001	-0.0003					
Skewness by standard deviation		-0.011					
ASYM5			0.265				
ASYM10				-0.172			
ASYMQ					6.50		
S5						**1.042**(*)	
S15							**1.115***
Standard error	0.0022	0.0022	0.0022	0.0022	0.0022	0.0021	0.0020
F test	1549**	1144**	1100**	1510**	1585**	1734**	1883**
Adjusted R^2	0.987	0.987	0.987	0.988	0.988	0.989	0.989
Autocorrelation	2.10(*)	2.08 (*)	2.17(*)	2.27(*)	2.17(*)	1.61	1.33
Heteroscedasticity	1.98(*)	1.45	2.86**	1.86(*)	3.37**	6.22**	6.71**

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors based on White (1980) are used for t-tests if heteroscedasticity was detected. Newey-West standard errors are used for t-tests if autocorrelation was detected.

III. Origins of Asymmetric Price Changes

In a next step, we analyse whether the asymmetry in prices can be attributed solely to supply conditions, as tentatively suggested by Ball and Mankiw (1995) and argued by Watanabe et al. (2003). Thus, in this section, we study more formally whether demand-side factors and the monetary environment affect the distribution of Japanese producer relative-price changes and thereby cast doubt on the supply-side interpretation during the quantitative easing period.

The developments in aggregate demand can be proxied by changes in shipments of industrial goods in the Industrial Production Index (IPI) published by the Ministry of Economy, Trade and Industry[6]. IPI also contains data on production and inventory, but we believe that shipment is a better proxy because production and inventory could reflect supply-side factors. It could be argued, however, that shipments are not necessarily equal to sales, and so we construct an additional indicator that is based on shipments adjusted for returns, measured as a change in inventory, within a period of three months.[7]

Table 3 contains estimates of the effects of the two demand indicators on the various proxies for asymmetry. Models (8)–(14) incorporate the effect of the change in shipments variables without accounting for returns. There is a positive and significant effect of demand conditions on the asymmetry of relative-price changes except in the case of ASYM5 and ASYM10. A similar conclusion holds when adjusting the demand indicator for returns within a three-month period, as can be seen from the outcomes of models (15)–(21). The explanatory power of demand is particularly high in the case of S15.

In the second analysis of factors influencing asymmetry indicators, we focus on the monetary environment. In deriving a proxy for the monetary environment during times of quantitative easing, we start with total current accounts of financial institutions held at the Bank of Japan and subtract reserve requirements, as these will limit private banks' ability to generate money. Thus, we concentrate on excess reserves that, arguably, lie at the heart of quantitative easing. To avoid problems of nonstationarity and provide a consistent proxy linking the monetary environment with long-run inflation, we standardise the variable with regard to production and the level of prices.[8]

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[6] Index of Industrial Production, see http://www.meti.go.jp/english/statistics/tyo/iip/h2afdlde.html.
[7] We also constructed the indicator with periods of one and two months, but doing so did not significantly change the results reported below.
[8] Starting from a variant of the quantity equation $M K = P Y$, with M = excess reserves, K = velocity, P = price level, and Y = output, we take logarithms and obtain $\ln(M/Y)_t + \ln k_t = \ln P_t$. Assuming that

Table 4 provides estimates of the effects of the monetary environment on the various asymmetry indicators. The outcomes of all models except model (24) reveal that the monetary environment has a significant effect on the various indicators of asymmetric relative-price changes. As before, the best fit is found in regressions on S15.

Typically, monetary developments take some time to carry over to prices, and thus it may be appropriate to specify longer adjustment lags. We do, indeed, find this to be the case in our dataset, as can be seen from the dynamic analysis below. However, in the present modelling framework, it can also be observed that using lags of the monetary environment indicator does not affect the significance of this variable. For instance, in the case of the skewness variable, the p-values for lags 2, 4, 6, and 8 of the monetary indicator are 0.001, 0.005, 0.01, and 0.02, respectively.

In summary, we find a significant effect of demand and monetary environment on the asymmetry indicators in the majority of our specifications. In our view, this creates doubt that these proposed price distribution indicators are pure proxies of supply conditions originating at the firm level. The above results suggest, instead, that these indicators also contain influences from the demand side and the monetary environment that also have sectoral effects. In our view, short-term inflation in Japan during the phase of quantitative easing can only be explained by several factors: demand side, supply side, and monetary environment.

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velocity equals unity and subtracting $\ln P_{t-1}$ from both sides of the equation yields $\ln(M/Y)_t - \ln P_{t-1} = \ln P_t - \ln P_{t-1}$. We then use $\ln(M/Y)_t - \ln P_{t-1}$ as indicator for the monetary environment.

Table 3: Explaining Indicators of Price Asymmetry by Demand Conditions

$$\text{Asymmetry Indicator}_t = \hat{\alpha} + \hat{\beta}_1 \text{Demand Indicator}_t + \varepsilon_t$$

Model	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.01**	0.83*	0.0003*	0.0007(*)	0.00003*	0.0002(*)	-0.00004
Demand conditions	**0.02***	**17.2****	0.002	0.001	**0.0004***	**0.005***	**0.008****
Standard error	0.004	2.66	0.001	0.0004	0.0001	0.001	0.001
F test	2.18	7.12**	0.49	1.32	4.74*	6.57*	11.95**
Adjusted R^2	0.02	0.09	-0.01	0.01	0.06	0.09	0.15
Autocorrelation	7.79	0.86	0.83	3.59*	0.45	0.22	0.45
Heteroscedasticity	0.34	0.17	0.14	0.38	0.06	0.11	0.43

Model	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.01**	0.64(*)	0.0003*	0.0006	0.00002(*)	0.001	-0.00004
Demand conditions excluding returns	**0.007***	**7.52***	0.001	0.0005	**0.0002***	**0.002***	**0.003****
Standard error	0.004	2.67	0.001	0.0004	0.0001	0.001	0.001
F test	2.14	6.28*	0.69	1.28	4.14*	5.16*	8.46**
Adjusted R^2	0.02	0.08	0.01	0.005	0.05	0.07	0.11
Autocorrelation	8.21	0.77	0.89	3.48*	0.39	0.22	0.66
Heteroscedasticity	0.46	0.58	0.31	0.41	0.36	0.44	0.67

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Newey-West standard errors are used for t-tests if autocorrelation was detected.

Table 4: Explaining Indicators of Price Asymmetry by the Monetary Environment

$$\text{Inflation}_t = \hat{\alpha} + \hat{\beta}_1 \text{Inflation}_{t-1} + \hat{\beta}_2 \text{Monetary Environmen t}_t + \hat{\beta}_3 \text{Asymmetry Indicator}_t + \varepsilon_t$$

Model	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.017**	5.43**	0.0007	0.0003*	0.0001**	0.001**	0.002**
Monetary environment	**0.0008****	**0.857****	0.0001	**0.00005***	**0.00002***	**0.0002***	**0.0003****
Standard error	0.004	2.62	0.001	0.0004	0.0001	0.001	0.001
F test	3.38(*)	9.04**	0.45	1.41	5.37*	7.06*	9.98**
Adjusted R^2	0.04	0.12	-0.01	0.02	0.07	0.09	0.16
Autocorrelation	8.66**	1.09	1.00	3.58*	0.28	0.24	0.28
Heteroscedasticity	0.60	1.41	0.18	1.53	0.37	0.01	0.07

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Newey-West standard errors are used for t-tests if autocorrelation was detected.

IV. The Impact of Asymmetric Price Changes, Demand Conditions, and the Monetary Environment on Inflation

In this section, we combine the various factors affecting short-run inflation into one model to investigate whether asymmetries in relative-price changes play a noteworthy role during this specific phase in Japanese monetary history. The first three models in Table 5 use skewness as the asymmetry indicator.[9] Model (29) shows that the significantly positive impact of the monetary environment on the inflation rate found in the bivariate context (results not shown) exists in a multivariate framework as well. Demand conditions are also significant, as can be seen in model (30). Moreover, model (31) indicates that this is the case even after controlling for returns to the producers three months after shipment. Switching the price asymmetry indicator from skewness to Asym5 and including both monetary environment and demand conditions, model (32) shows that the former is not significant, while the latter are. Moreover, there is notable collinearity between monetary environment and demand conditions, which implies that jointly they are even significant at a 1% level ($F(2, 57) = 5.02^{**}$). An equivalent conclusion holds in the case of Asym10 in model (33), AsymQ in model (34), and S5 in model (35).

Employing the Watanabe et al. (2003) indicator S15 in model (36), we arrive at a somewhat different outcome: now, price asymmetries matter and they have a significantly positive effect on inflation, in line with the hypothesis advanced by Ball and Mankiw (1995). However, demand continues to have a significant influence on inflation rates. Moreover, it was shown above in models (15) and (21) that demand has a significant effect on S15, which implies that demand affects inflation over and above its influence on the asymmetry of relative-changes in prices. Model (28) demonstrates that for S15, the monetary environment variable has the highest explanatory power of any asymmetry indicator. Hence, to some extent, S15 reflects the influence of the monetary environment. Thus, even in the only model where an asymmetry indicator significantly explains inflation, we still find a significant influence of factors that are unrelated to supply.

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[9] Note that the interaction of skewness and standard deviation, which showed a great deal of promise in Ball and Mankiw's (1995) study, is never significant in any of the constellations we look at and has been omitted in the interest of brevity.

Table 5: Explaining Producer Price Inflation by Asymmetric Price Changes, Demand Conditions, and the Monetary Environment

$$\text{Inflation}_t = \hat{\alpha} + \hat{\beta}_1 \text{Inflation}_{t-1} + \hat{\beta}_2 \text{Standard Deviation}_t + \hat{\beta}_3 \text{Asymmetry Indicator}_t + \hat{\beta}_4 \text{Monetary Environment}_t + \hat{\beta}_5 \text{Demand Conditions}_t + \varepsilon_t$$

Model	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
Constant	0.0005	-0.002**	-0.003**	-0.001	-0.001	-0.001	-0.001	-0.001
Lagged inflation	0.981**	0.973**	0.985**	0.971**	0.971**	0.968**	0.967**	0.961**
Standard deviation	0.235**	0.232**	0.230**	0.218**	0.236**	0.194**	0.191(*)	0.176(*)
Skewness	0.0001	0.0001	0.0001					
ASYM5				0.203				
ASYM10					-0.178			
ASYMQ						4.767		
S5							0.829	
S15								**0.909***
Monetary environment	**0.0005(*)**			0.0003	0.0003	0.0002	0.0002	0.0002
Demand conditions		**0.019****		**0.016***	**0.017****	**0.016***	**0.015****	**0.013***
Demand conditions excluding returns			**0.008****					
Standard error	0.0022	0.0021	0.0021	0.0021	0.0021	0.0020	0.0020	0.0019
F test	1210**	1338**	1328**	1066**	1058**	1090**	1167**	1241**
Adjusted R^2	0.988	0.989	0.989	0.989	0.989	0.989	0.990	0.990
Autocorrelation	2.05	1.19	1.77	1.17	1.20	1.23	0.90	0.82
Heteroscedasticity	1.52	1.26	1.51	1.56	3.46**	1.23	3.11**	4.31**

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors based on White (1980) are used for t-tests if heteroscedasticity was detected.

Our findings suggest that demand conditions and monetary environment affect inflation through two channels: (i) directly and (ii) indirectly via a significant impact of these two factors on the S15 Watanabe et al. (2003) price asymmetry indicator. To sum up, inflation during the period quantitative easing was influenced by the monetary environment, demand conditions, and supply conditions as proxied by asymmetries in relative-price changes. In the next step of our analysis, we look more closely at the dynamic relationship between these variables.

V. Dynamic Impact of Supply, Demand, and Monetary Shocks on Inflation

To analyse the dynamics between supply, demand, and monetary shocks, we estimate vector autoregressive (VAR) models. We employ variables in levels, which yields a convenient interpretation in terms of shocks.[10] As before, we follow Ball and Mankiw (1995) by using the more theory-consistent producer price index, with skewness as the supply-side indicator and controlling for the standard deviation. As shown above, the alternative indicators for price asymmetries put forward by these authors behave rather similarly. However, at least in the period of quantitative easing in Japan, the Watanabe et al. (2003) indicator S15 appears to be a much stronger predictor of inflation. It thus will be interesting to see whether using this variable as an alternative to skewness affects the outcome of the analysis. In addition, we control for international supply-side shocks with the help of an index of energy prices.[11] Monetary shocks are derived by including excess reserves held by private financial institutions at the Bank of Japan, and demand shocks reflect the delivery of goods.

Choice of the length of the VARs is based on information criteria and is set at 2 lags. To avoid ambiguities in the results of the impulse response functions arising from an arbitrary

[10] By using level variables, despite the fact that some could be nonstationary, we follow the argument in Sims and Uhlig (1991).

[11] Taken from the import price index of the Bank of Japan's producer price series (see footnote 7).

ordering of the variables, we use generalised impulse responses (Pesaran and Shin 1998), which generate an orthogonal set of innovations that does not depend on the VAR ordering. The confidence bands are derived using analytic methods based on asymptotic theory and provide significant tests at a significance level of approximately 5%.

Figure 2 illustrates the dynamic reaction of producer prices to a one standard deviation shock in the assorted variables. A shock in energy prices causes an increase in the price level, which meets our expectations as to a supply shock. An increase in the standard deviation yields higher prices, and so does more skewness. Thus, in a dynamic setting, we find evidence that the variables put forward by Ball and Mankiw (1995) explain price developments in Japan during the period of quantitative easing. In addition, demand shocks also move prices upward, as do monetary shocks. The time profiles of the price reactions to these variables appear to be plausible, with demand shocks generating a quick impact on prices and monetary shocks being characterised by longer transmission lags.

Substituting skewness for the price asymmetry indicator suggested by Watanabe et al. (2003) paints a similar picture (see Figure 3). The price asymmetry effect is even more pronounced, whereas the impacts of demand and monetary shocks are basically unchanged. Thus, prices in Japan react to asymmetry shocks as well as to demand and monetary shocks.

However, the above results indicate that the asymmetry indicator should not be interpreted as reflecting pure supply-side effects. The VAR framework allows investigating the relationship between price asymmetry indicators in a dynamic setting. Figure 4 shows how skewness reacts to shocks in the other variables. First, note that the dynamic adjustments do not last as long as in the case of producer prices. Second, skewness increases after a price shock. Thus, there appears to be a feedback relationship between skewness and price level.

Third, energy prices affect skewness positively, whereas the standard deviation does not have much effect at all on skewness, a result that runs counter to the relationship expected by Ball and Mankiw (1995). Fourth, a monetary shock has a positive, albeit small, effect on skewness. Fifth, there is a statistically significant and economically relevant positive effect of demand shocks on skewness. Figure 5 investigates the dynamic response of S15 as an indicator of asymmetries in relative-price changes. The qualitative results do not change. However, one notable difference is how much more strongly the price asymmetry indicator reacts to producer price shocks and energy price shocks. The feedback relationship between prices and the asymmetry indicator noted above is even stronger in this case.

The other effects within the VAR are rather complicated. Figure 6 is a stylised summary of the relationship between producer prices, skewness, and the other indicators based on the impulse response functions. In the interests of clarity, in this figure we concentrate on the shocks affecting the three PPI-related variables that are both statistically significant as well as quantitatively relevant. The arrows indicate significantly positive effects of shocks in one variable on another variable. Thus, all the listed factors increase producer prices in Japan. However, in addition to these direct effects, demand-side shocks increase skewness. Thus, as a result of higher demand, producer prices increase directly and indirectly through the mechanism outlined by Ball and Mankiw (1995). Thus, skewness cannot be interpreted as a pure supply-side indicator.

Figure 2: Responses of the Producer Price Index to Orthogonal Shocks (Including Skewness)
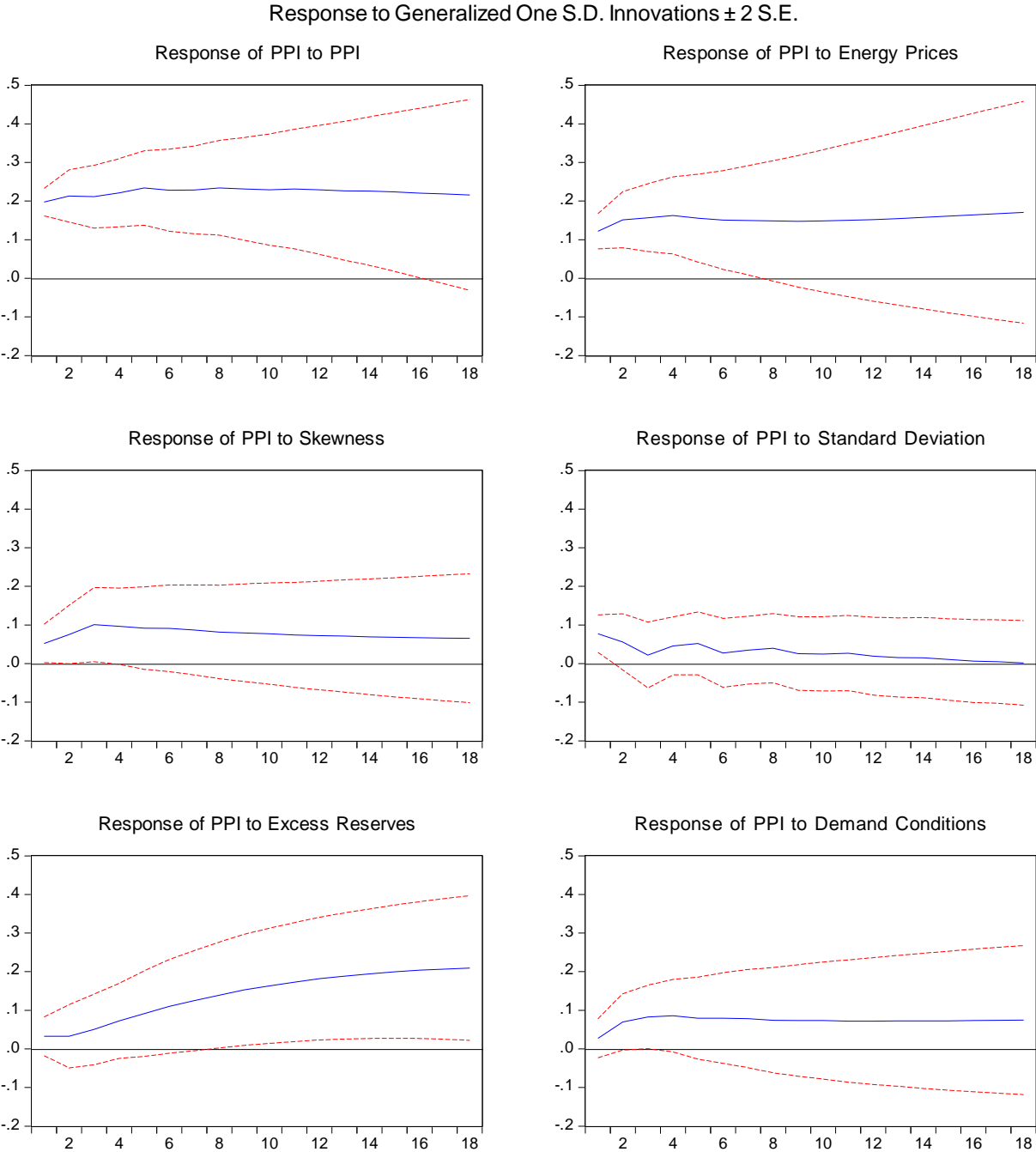
Response to Generalized One S.D. Innovations ± 2 S.E.

Response of PPI to PPI

Response of PPI to Energy Prices

Response of PPI to Skewness

Response of PPI to Standard Deviation

Response of PPI to Excess Reserves

Response of PPI to Demand Conditions

Figure 3: Responses of the Producer Price Index to Orthogonal Shocks (Including S15)

Response to Generalized One S.D. Innovations ± 2 S.E.

Response of PPI to PPI

Response of PPI to Energy Prices

Response of PPI to S15

Response of PPI to Standard Deviation

Response of PPI to Excess Reserves

Response of PPI to Demand Conditions
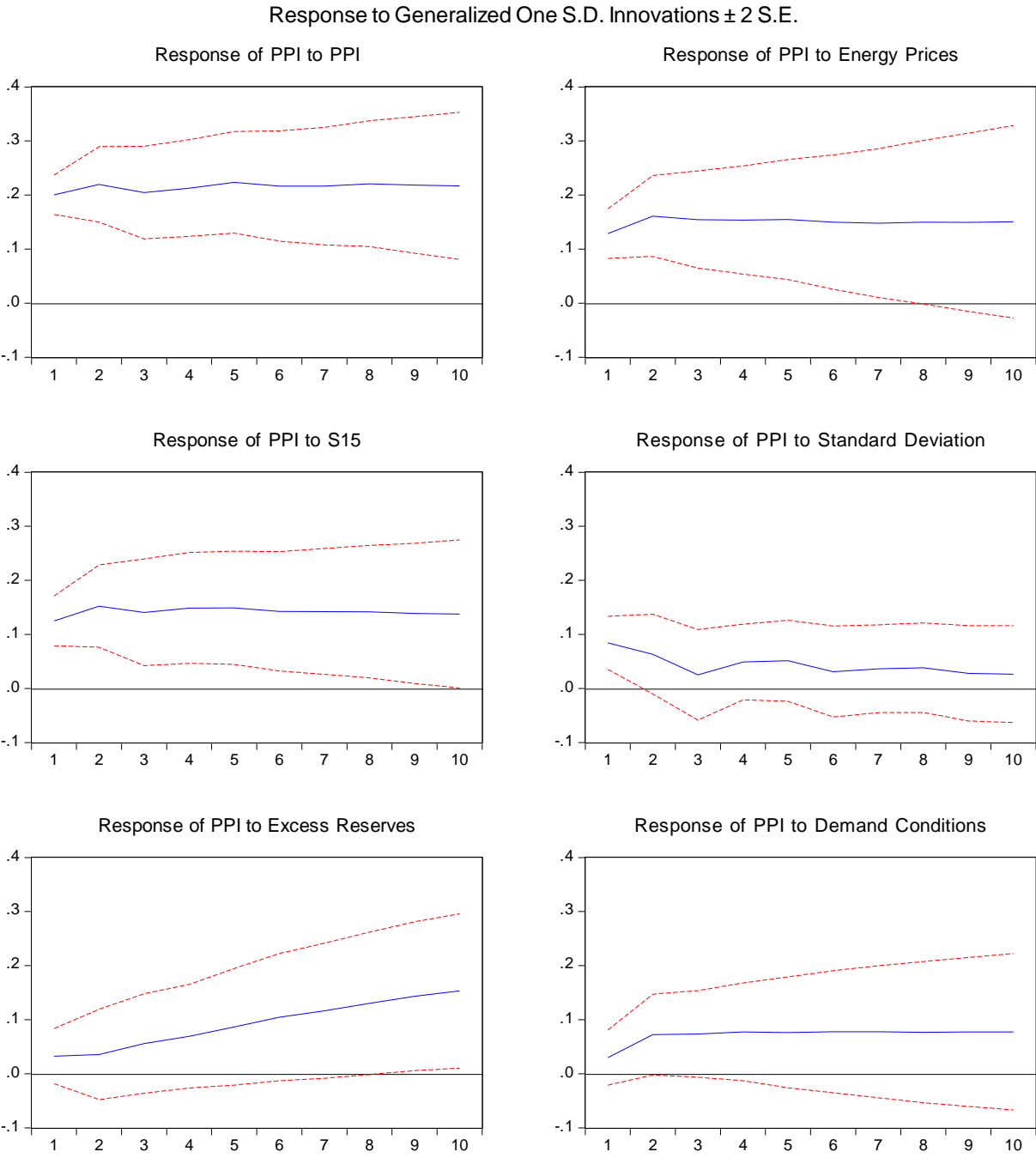
Figure 4: Responses of Skewness to Orthogonal Shocks

Response to Generalized One S.D. Innovations ± 2 S.E.
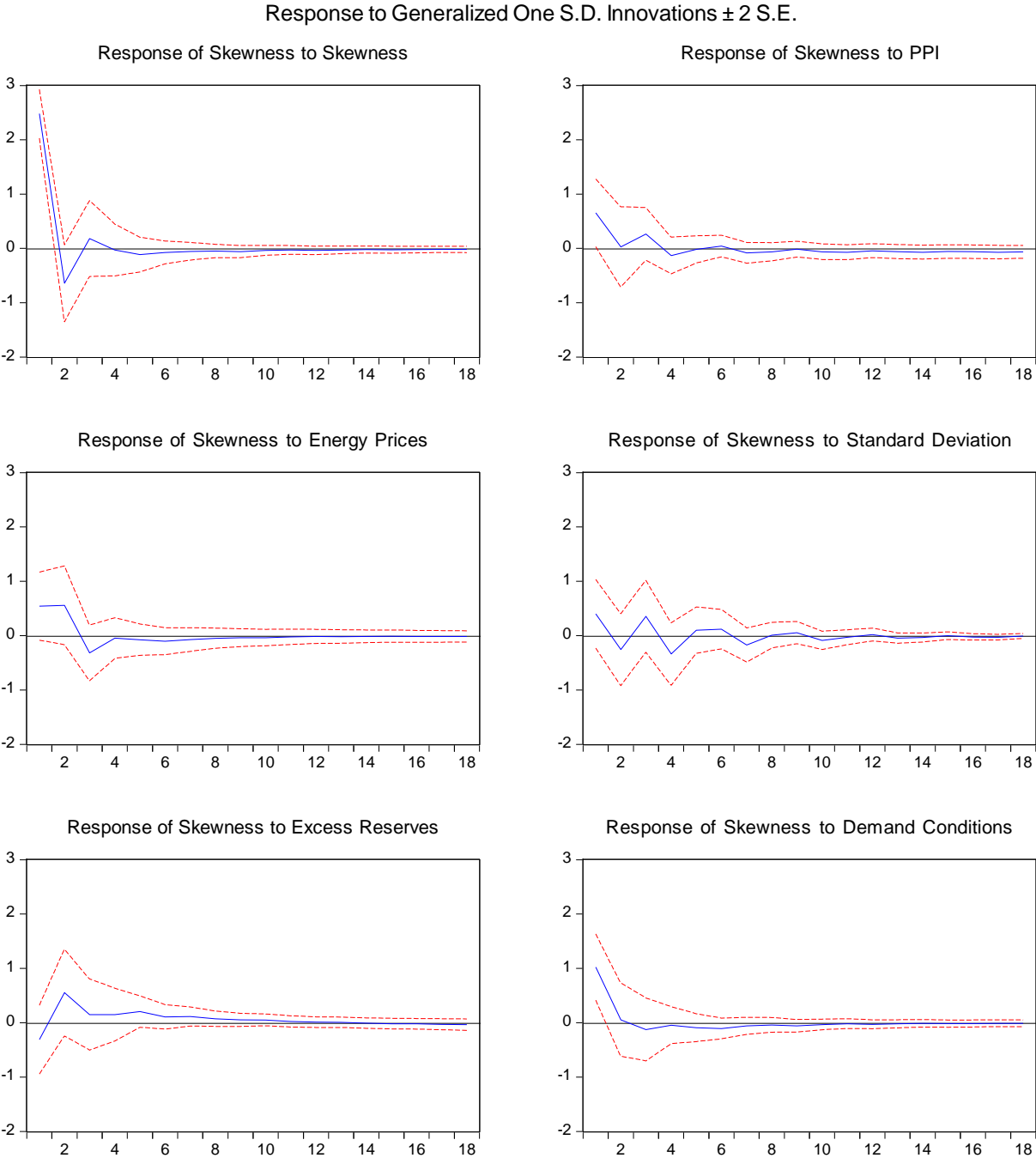
Figure 5: Responses of S15 to Orthogonal Shocks

Response to Generalized One S.D. Innovations ± 2 S.E.

Response of S15 to S15

Response of S15 to PPI

Response of S15 to Energy Prices

Response of S15 to Standard Deviation

Response of S15 to Excess Reserves
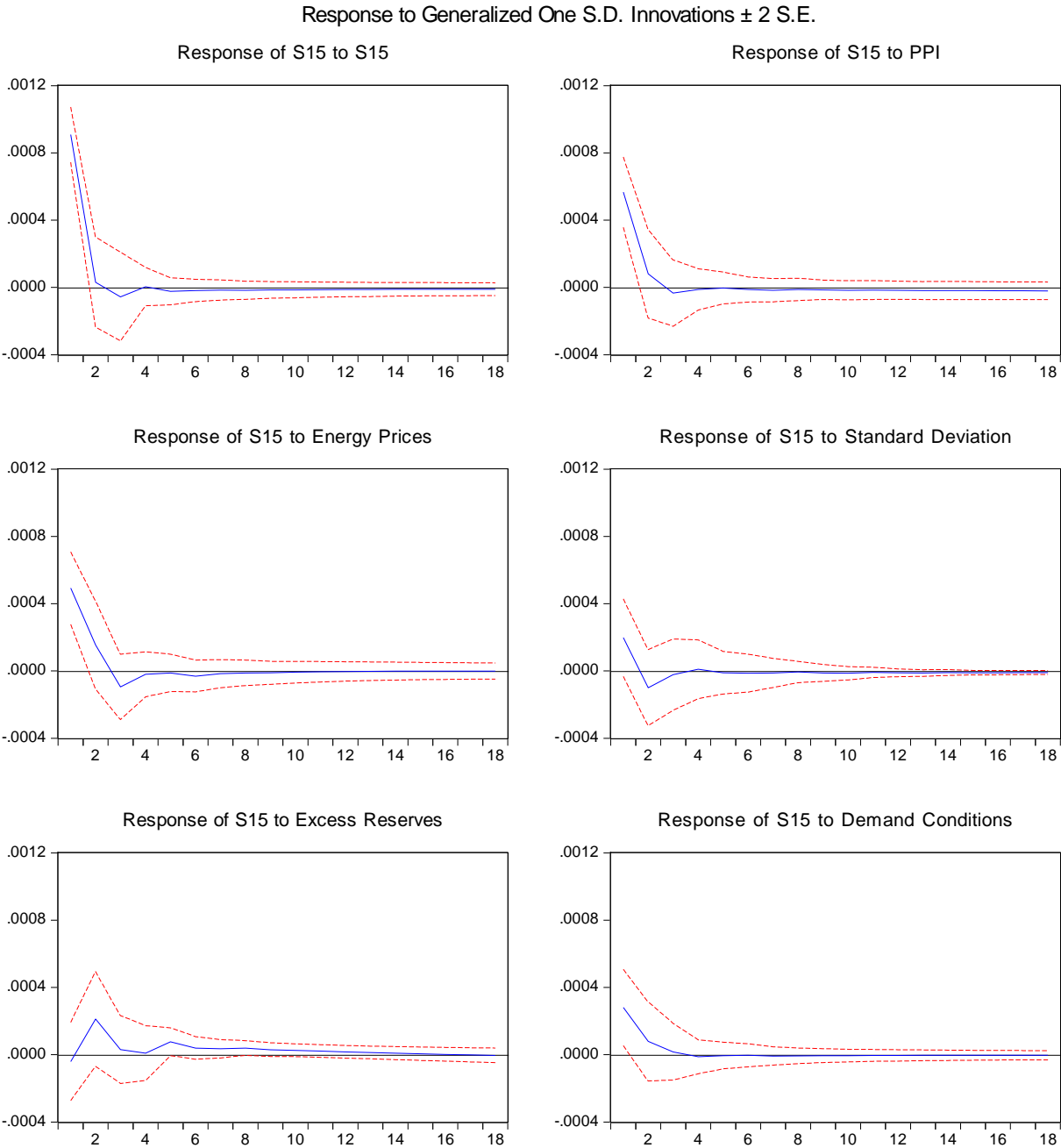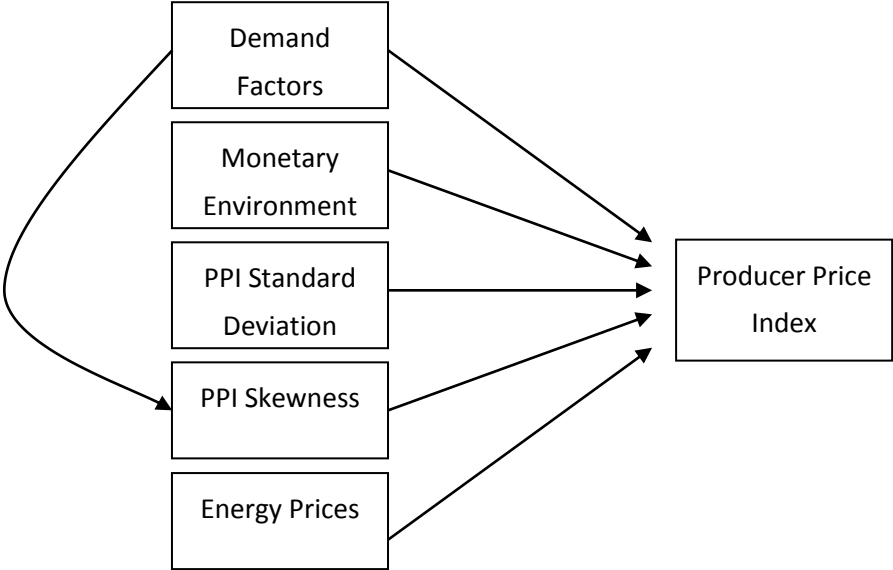
Response of S15 to Demand Conditions

Figure 6: Relationship Between Producer Prices, Skewness, Monetary Environment, and Demand Factors

VI. Conclusions

Japan has been experiencing disinflation/deflation for almost 20 years and the debate over why can be roughly characterised as one of 'supply versus demand'. In debates of this sort, Ball and Mankiw's (1995) influential theory based in New Keynesian economics has received a great deal of attention, although the specific case of Japan is not often addressed. Many researchers interpret the theory as a supply-side hypothesis for short-run inflation, and suggest that the detected positive correlation between the asymmetry of sectoral relative-price changes and inflation supports the hypothesis. This paper reexamines this correlation and investigates whether monetary environment and aggregate demand can also explain the inflation rate during the quantitative easing period in Japan.

Using monthly data from the producer price index for the period March 2001 to March 2006, we first showed that the positive and significant effect of relative-price change asymmetries on inflation is not robust with respect to various indicators of asymmetry. We then showed

that indicators of aggregate demand and monetary environment *do* affect measures of asymmetries and discovered that demand factors play a particularly noteworthy role in explaining inflation. In our examination of the dynamic impact of various factors on inflation, we obtained robust evidence from impulse responses based on vector autoregressive models that demand and monetary environment influence inflation and that aggregate demand also, significantly and substantially, affects the asymmetry of relative price-changes. From these results, we conclude that, at least for the quantitative easing period in Japan, it is overly simplistic to regard disinflation/deflation as a supply-side phenomenon only. The demand side is also an important determining factor.

This study concentrates on the period of quantitative easing by the Bank of Japan; extending the period of study would be of interest. A precondition for such an analysis, however, would be to accommodate quite different indicators of monetary shocks. It may also be important to address the small sample issue pointed out by Bryan and Cecchetti (1999), possibly by following suggestions made by Gerlach and Kugler (2007). Further, the result of this study is *indicative* that monetary shocks and other determinants of aggregate demand *could* have a different influence across various sectors, but we do not directly examine such a possibility. In this respect, direct evidence on asymmetric sectoral effects of shocks in demand and monetary policy (Hayo and Uhlenbrock 2000, Dedola and Lippi 2005) would complement this study and lend support to its claim.

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