Understanding Output and Price Dynamics in Japan: Why Have Japan's Price Movements Been Relatively Stable Since the 1990s?[*]

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Abstract

Since the beginning of the 1990s, Japanese inflation has been relatively stable with slight declines, while output has remained volatile with a prolonged stagnation. This paper attempts to explore possible explanations for these macroeconomic facts based on the aggregate demand and supply framework. Specifically, applying a vector autoregressive framework that allows for correlations between structural disturbances, it examines two broad questions in a unified way: (i) whether the slope of the short-run aggregate supply curve became significantly flattened and/or (ii) whether structural demand and supply shocks are more strongly positive correlated. Our results suggest that positive correlation between structural demand and supply shocks has become stronger since the 1990s, while there is less evidence that the short-run aggregate supply curve has been flattened. We argue that shifts in aggregate demand and supply curves in the same direction lead to larger, permanent effects on output and to limited effects on prices in Japan.

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1 Introduction

This paper is motivated by the macroeconomic developments in Japan since the early 1990s. During the long stagnation of the Japanese economy (sometimes called "Japan's lost decade"), inflation has been relatively stable with slight declines. In other words, fluctuations in output have remained volatile as before, while price fluctuations have been fairly small over the last decade. This may contrast with the cases of the US, Euro area and UK, where there has been a sharp decline in the volatility of both inflation and output growth since the mid-1980s, the phenomenon which is widely known as "Great Moderation".[1]

The above time series characteristics of the Japanese economy can be readily confirmed by the data. Figure 1 displays a scatter plot of output growth (i.e. monthly growth rate of the index of industrial production (IIP)) and inflation (i.e. monthly growth rate of consumer price index (CPI)) in Japan.[2] The upper graph shows the relationship for the pre-1992 period (February 1978–December 1991) and the lower graph for the post-1992 period (January 1992–December 2006). We observe that output fluctuations remained similar between the two periods, while price fluctuations became more stable in the post-1992 period (see the lower graph). Table 1 presents the mean, standard deviation, and range between minimum and maximum values of output and inflation for the two periods. This also indicates that output growth remained highly volatile as before. Both the variance and range of the Japanese IIP growth rate remained very large. On the other hand, CPI inflation has been relatively stable since 1992. While the mean of inflation slightly declined, both the standard deviation and range of Japanese inflation become reduced in

[1]Several studies have addressed the issue of the "Great Moderation". For example, Blanchard and Simon (2001) report a decline in the volatility of real activity and inflation in the US and a reduction in the persistence of inflation since the early 1980s. Canova et al. (2007) examine the nature and the source of the structural changes in the dynamics of output growth and inflation in the US, Euro area and UK using structural time varying coefficient vector autoregressive model. Stock and Watson (2005) investigate the sources of the changes in volatility of economic activity in G7. They suggest that, with the exception of Japan, a significant portion of the widespread reduction in volatility is associated with a reduction in the magnitude of the common international shocks. They find that, during the 1980s and 1990s, cyclical fluctuations in Japanese GDP became almost detached from the other G7 economies, with domestic shocks explaining almost all of the cyclical movements in Japanese GDP.

[2]IIP(Mining and Manufacturing, 2000 = 100) and CPI(General, 2000 = 100) are taken from the Nikkei NEEDS database. They are seasonally adjusted by Census X12 ARIMA. To filter out the effect of the introduction of the consumption tax on inflation and the rise of individually paid medical expense, 1.2% is subtracted from the CPI inflation series at April 1989 and 1.5% is subtracted from the CPI inflation series at April 1997, following Jinushi et al. (2000).

size.

So why has Japan's inflation become relatively stable since the 1990s? Using a standard short-run tool of aggregate demand-supply (AD-AS) model, there are at least two broad possibilities. The first is that the short-run supply curve has become flattened since the 1990s and shifts in aggregate demand led to large output fluctuations with relatively stable movements in prices.[3] The second is the possibility that shifts in demand and supply curves have become strongly positively correlated. As Figure 2 illustrates, when AD and AS curves shift together in the same direction, output movements become large (between A and B) while price fluctuations remain relatively small (between C and D).

There are especially good reasons to incorporate the second possibility into our analysis because demand shortage may be correlated with productivity slowdown through several channels over the last decade of Japan's economic stagnation. For example, responding to demand shocks, firms may change output rather than prices because of nominal and/or real rigidity (see Ball et al., 1988; Ball and Romer, 1990). Demand shocks can have effects on the supply side so long as technological progress is endogenously determined by the amount of resources (see Stadler, 1990; Pelloni, 1997; Fatas, 2000). In the context of the Japanese economy, the linkage between AD and AS sides may be even stronger. For instance, when demand is stagnant, firms may reduce regular employment and/or R&D investments, all of which may have adverse effects on human capital and total factor productivity of the economy. Prolonged economic stagnation may further increase bad loans in the banking sector, which deteriorates the efficiency of resource allocation of the economy.[4]

To analyze these two hypotheses under a unified framework, we employ an econometric procedure developed by Cover et al. (2006) and apply their methodology to the Japanese economy. Cover et al.'s approach suits the present objective fairly well in that (i) it allows for a correlation between structural demand and supply disturbances under a bivariate AD-AS framework and (ii) it can also estimate the slope of the short-run supply curve

[3] Nishizaki and Watanabe (2000) estimate the nonlinear short-run Phillips curve using the Japanese data, and assert that the slope of the short-run Phillips curve becomes flatter as the rate of inflation approaches zero. Note that their analysis covers the period until 1997. A flatter Phillips curve generally implies that prices and/or wages become stickier, but whether this is true in the late 1990s or 2000s warrants further scrutiny. See e.g. Kimura and Ueda (2001).

[4] The causation may also run in an opposite direction. See footnote 8 and 17 for further discussion.

relationship in the context of a new classical type model. We extend their analysis by examining a possible structural break of the Japanese economy in the early 1990s.

Note further that our empirical examination is novel in the literature of Japan's lost decade. Many existing discussions tend to seek for explanations from either the supply side or demand side of the economy, and the interactions of these two factors may not be analyzed explicitly.[5]

Summarizing the main results of this paper, we find that (i) compared to the possibility of intensifying AD-AS interaction, there is less evidence that the short-run AS curve has been flattened, (ii) positive correlations between the demand and supply shocks have been stronger since the 1990s, and (iii) shifts in AD and AS curves in the same direction lead to larger and long-run effects on output and limited effects on prices. These findings suggest that relatively stable price fluctuations and the prolonged slowdown of the Japanese economy since 1990s is due not just to either demand side or supply side factors, but to both. The strong interrelation between demand and supply shocks is the key to understand Japan's output and price movements over the last decade.

The remainder of the paper is structured as follows. Section 2, following Cover et al. (2006), shows the econometric framework used in this paper. Section 3 reports the empirical results. Some concluding remarks are offered in the final section.

2 Econometric Framework

Following Cover et al. (2006), this section shows the econometric framework used in this paper. They consider estimation of the slope of the aggregate supply curve in the context of a new classical-type model, the variance of structural demand and supply shocks, and the extent to which the supply and demand curves shift together.

[5] A large number of studies analyzed the cause of the prolonged slowdown of the Japanese economy since 1990s. Kuttner and Posen (2001), Bayoumi (2001), and Horioka (2006) emphasize the importance of demand side factors. They mainly rely on the Keynesian view that the shortage of aggregate demand is the cause, such as the stagnation of investment due to credit crunches (a sharp reduction in bank lending supply), increased uncertainty about future prospects for the Japanese economy, and inadequate monetary and fiscal stimulus leading to inadequate aggregate demand. On the other hand, Hayashi and Prescott (2002), Caballero et al. (2006), and Kobayashi and Inaba (2006) emphasize the importance of supply side factors. These authors stress sustained decline in productivity, such as decline in the pace of technological change, inefficiency in resource allocation due to forbearance lending by banks and wasteful public spending, and inefficiency in the labor market due to a rise in real wages caused by the stickiness of nominal wages and disinflation. These two broad views have often been presented independently, but the potentially important interactions have not been thoroughly investigated.

Let y_t and p_t, respectively, be the logarithms of output and the price level during period t. Consider the following bivariate vector autoregressive (VAR) model in which e_{yt} and e_{pt}, respectively, are the random disturbances in the output growth Δy_t and inflation Δp_t equations, a_1, a_2 are constants, the $a_{ij}(L)$ are polynomials of order n in the lag operator, L, or $a_{ij}(L) = \sum_{k=1}^{n} a_{ij}(k)L^k$:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} a_{11}(L) & a_{12}(L) \\ a_{21}(L) & a_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix}. \tag{1}$$

To provide the economic interpretation to the reduced-form VAR model (1), consider an AD-AS model:

$$y_t^s = E_{t-1}y_t + \alpha(p_t - E_{t-1}p_t) + \epsilon_t, \quad \alpha > 0, \tag{2}$$

$$(y_t + p_t)^d = E_{t-1}(y_t + p_t)^d + \eta_t, \tag{3}$$

$$y_t^d = y_t^s, \tag{4}$$

where E_{t-1} denotes a expectation conditional on time $t-1$ information, and the superscripts s and d represent supply and demand. ϵ_t and η_t denote the serially uncorrelated structural AS and AD shocks, respectively. Equation (2) is a new classical-type short-run AS curve in which output increases in response to unexpected increases in price level plus an AS shock ϵ_t. The parameter α indicates how much output responds to unexpected changes in the price level. This means that, when prices are sticky due to nominal rigidities, etc, the AS curve is upward sloping, and shifts in the AD curve do cause the level of output to deviate from the natural rate (equilibrium output in the case of fully flexible prices).[6] Equation (3) is the simple AD relationship; nominal AD equals its expected value plus an AD shock, η_t.

Solve equation (2)–(4) for Δy and Δp as follows:

$$\Delta y_t = E_{t-1}\Delta y_t + \frac{\alpha}{1+\alpha}\Delta\eta_t + \frac{1}{1+\alpha}\Delta\epsilon_t \tag{5}$$

$$\Delta p_t = E_{t-1}\Delta p_t + \frac{1}{1+\alpha}\Delta\eta_t - \frac{1}{1+\alpha}\Delta\epsilon_t \tag{6}$$

[6] There are some models to explain the short-run AS. For example, see Mankiw (2002), pp. 347–358.

We find that the immediate effects of a demand or a supply shock depend on the parameter α. Equation (5) means that the immediate effects of a 1% demand shock ($\Delta\eta_t$) and a 1% supply shock ($\Delta\epsilon_t$) on output are $\alpha/(1+\alpha)$ and $1/(1+\alpha)$, respectively. And, equation (6) means that the immediate effects of a 1% demand shock and a 1% supply shock on prices are $1/(1+\alpha)$ and $-1/(1+\alpha)$, respectively.

If it is assumed that $E_{t-1}\Delta y_t$ and $E_{t-1}\Delta p_t$ are equal to linear combinations of their past observed values, the results can be written in a form similar to equation (1), which yields:

$$\begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \Delta\epsilon_t \\ \Delta\eta_t \end{bmatrix} \tag{7}$$

so that the covariance matrix Σ_e is

$$\begin{bmatrix} Var(e_y) & Cov(e_y, e_p) \\ Cov(e_y, e_p) & Var(e_p) \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \sigma_\epsilon^2 & \sigma_{\epsilon\eta} \\ \sigma_{\epsilon\eta} & \sigma_\eta^2 \end{bmatrix} \begin{bmatrix} \frac{1}{1+\alpha} & \frac{-1}{1+\alpha} \\ \frac{\alpha}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix}. \tag{8}$$

The essential feature of this estimation approach is the absence of a restriction forcing the AD and AS shocks to be contemporaneously uncorrelated.

In order to achieve full identification of the structural parameters of the new classical-type AD-AS model as above, Cover et al. (2006) introduce the Blanchard and Quah (1989) restriction. Blanchard and Quah (1989) interpret that, due to nominal rigidities, etc, demand disturbances have short-run effects on output, but these effects disappear over time. This implies that the long-run AS curve is vertical, because shifts in the AD curve affect the price level while the output of the economy is back at its natural rate in the long-run. We think of the demand shocks η_t as the occurrence of transitory disturbances to the natural rate of output.[7] But, unlike Blanchard and Quah (1989), this estimation approach allows the possibility of the correlation between the demand and supply curve shifts.

[7] The natural rate of output (the equilibrium level in the case of flexible prices) differs from the efficient level which is the equilibrium level in the case that, under flexible prices, there is no distortion owing to, for example, the existence of distorting taxes on sales revenues or labor income and the distortions created by market power.

From Equation (1), we obtain

$$
\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} 1-a_{11}(L) & -a_{12}(L) \\ -a_{21}(L) & 1-a_{22}(L) \end{bmatrix}^{-1} \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \Delta\epsilon_t \\ \Delta\eta_t \end{bmatrix}
$$

$$
= \frac{1}{\left| \begin{bmatrix} 1-a_{11}(L) & -a_{12}(L) \\ -a_{21}(L) & 1-a_{22}(L) \end{bmatrix} \right|} \begin{bmatrix} \cdots & (1-a_{22}(L))\frac{\alpha}{1+\alpha} + a_{12}(L)\frac{1}{1+\alpha} \\ \cdots & \cdots \end{bmatrix} \begin{bmatrix} \Delta\epsilon_t \\ \Delta\eta_t \end{bmatrix}.
$$

The Blanchard and Quah (1989) restriction implies that

$$
\begin{aligned}
(1-a_{22}(1))\frac{\alpha}{1+\alpha} + a_{12}(1)\frac{1}{1+\alpha} &= 0 \\
\Rightarrow \alpha &= \frac{-a_{12}(1)}{1-a_{22}(1)},
\end{aligned} \tag{9}
$$

which yields an estimate of α. Once the estimate of α is obtained, equation(8) can be used to solve for $\sigma_\epsilon^2, \sigma_\eta^2$, and $\sigma_{\epsilon\eta}$.

To estimate the structural parameters of the AD-AS model, it is not necessary to assume that structural shocks are mutually uncorrelated in order to identify the structural demand and supply shocks. However, in order to obtain the impulse responses, it is necessary to identify orthogonal structural shocks. Here, we consider that an AD shock causes the AS curve as well as the AD curve to contemporaneously shift.[8] This can be implemented by assuming that unexpected AS equals an 'exogenous' AS shock, δ_t, plus an endogenous change in AS that is induced by the AD shock, $\gamma\eta_t$,

$$
\epsilon_t = \gamma\eta_t + \delta_t. \tag{10}
$$

[8] Alternatively, we can also consider that an AS shock causes the AD curve as well as the AS curve to contemporaneously shift. When the components of AD have a forward-looking and a shock to AS has a permanent effect on output, then the shock will raise the present value of future income of households and future profits of firms to the level which is higher than initially expected, and accordingly have a considerable effect on current demand. Miyao (2006) asserts that supply-side factors such as low productivity can be linked with AD, and these factors are the main factor behind the persistent shortage of AD since the 1990s. For the results, see footnote 17.

If equation (10) is substituted into equations (7) and (8), the result is:

$$
\begin{bmatrix} Var(e_y) & Cov(e_y, e_p) \\ Cov(e_y, e_p) & Var(e_p) \end{bmatrix}
$$
$$
= \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} 1 & \gamma \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \sigma_\delta^2 & 0 \\ 0 & \sigma_\eta^2 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \gamma & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{1+\alpha} & \frac{-1}{1+\alpha} \\ \frac{\alpha}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \tag{11}
$$
$$
= \begin{bmatrix} \frac{1}{1+\alpha}\sigma_\delta & \frac{\gamma+\alpha}{1+\alpha}\sigma_\eta \\ \frac{-1}{1+\alpha}\sigma_\delta & \frac{1-\gamma}{1+\alpha}\sigma_\eta \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{1+\alpha}\sigma_\delta & \frac{-1}{1+\alpha}\sigma_\delta \\ \frac{\gamma+\alpha}{1+\alpha}\sigma_\eta & \frac{1-\gamma}{1+\alpha}\sigma_\eta \end{bmatrix} \tag{12}
$$

The relationship in which an AD shock leads to a shift in the AS curve can arise when the rate of technological progress is related to the level of output, for example because of learning-by-doing. As Stadler (1990), Pelloni (1997) and Fatas (2000) show, demand shocks that change the level of output can have an impact on the supply side through endogenous technological change. For example, when demand is stagnant, firms may reduce regular employment, and unemployed workers may lose some of their skills. Lower levels of output may make innovation less profitable and result in the allocation of less resources to R&D investments. Prolonged economic stagnation may further increase bad loans in the banking sector, which deteriorates the efficiency of resource allocation of the economy.

Certainly, if the positive correlation between the AD and AS curve shifts is small, the supply side effects of an AD shock are negligible.[9] However, especially in the context of the Japanese economy since the 1990s, if its correlation is large, we expect that there are some significant influences on the dynamic responses of both AD and AS shifts on output and prices.

3 Empirical Results

This section presents the empirical results based on the structural VAR framework just described. Output y_t is measured as the logarithm of the IIP (Mining and Manufacturing).

[9] Blanchard and Quah (1989) agree that demand shocks have a long-run impact on output. However, they point out that their restriction, in which a demand shock has no long-run effect on output, is nearly correct if the long-run effects of a demand shock are small compared to those of a supply shock.

Price p_t is measured as the logarithm of the CPI (general).[10] The data spans the period from February 1978 through November 2006. The lag length is set to ten in the estimation of the reduced-form model (1).[11]

We offer three sets of results: (i) results from testing our model for structural stability, (ii) comparison of the estimated structural parameters for the AD-AS model between the two subsamples, and (iii) comparison of output and price responses to an AD or AS shock between the two subsamples.

3.1 Testing for Structural Stability

This subsection provides the results from testing our model for structural stability. To confirm whether there is a structural break in the VAR system, we test the structural stability of our reduced-form VAR models defined by (1), applying a procedure used by Cecchetti and Karras (1994) and Miyao (2000).

The procedure is a test of whether the overall parameter values are unchanged between the two periods before and after a given possible break date. Thus, the null hypothesis that all the model parameters are the same is tested against the alternative of a structural shift. In this method, we estimate the following reduced-form system:

$$\begin{aligned}\begin{bmatrix}\Delta y_t \\ \Delta p_t\end{bmatrix} &= \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} a_{11}(L) & a_{12}(L) \\ a_{21}(L) & a_{22}(L)\end{bmatrix}\begin{bmatrix}\Delta y_t \\ \Delta p_t\end{bmatrix} \\ &\quad + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} d_t + \begin{bmatrix} b_{11}(L) & b_{12}(L) \\ b_{21}(L) & b_{22}(L)\end{bmatrix}\begin{bmatrix}\Delta y_t \\ \Delta p_t\end{bmatrix} d_t + \begin{bmatrix}\xi_{yt} \\ \xi_{pt}\end{bmatrix} \end{aligned} \tag{13}$$

where the b_1, b_2 are constants, the $b_{ij}(L)$ are polynomials of order n in the lag operator, L, or $b_{ij}(L) = \sum_{k=1}^{n} b_{ij}(k)L^k$, d_t is a dummy variable which is set to one after a given

[10] We run two unit root tests (a Dickey-Fuller GLS test and a Phillips and Perron test) for the variables in first differences. The tests include a constant term only. We confirmed that the null of a unit root is rejected for all cases.

[11] We perform a modified likelihood ratio (LR) test proposed by Sims (1980) to check whether taking ten lags is sufficient. Here, the null of ten lags is tested against the alternative of 11 lags. The LR statistics indicate that the null is not rejected by conventional significance levels. Also, we perform the multivariate lagrange multiplier (LM) test statistics for residual serial correlation for up to $\{1, \cdots, 13\}$th order. See Johansen (1995), p. 22 for the formula of the LM statistic. The LM statistics for each order indicate that the null hypothesis of no serial correlation is not rejected by asymptotically significance levels. Furthermore, when long-run restrictions are used for identification of the VAR model, the lag length of VAR also plays a role of identifying restriction. See Faust and Leeper (1997) for details. However, the results obtained with 10 lags are generally similar to those obtained with any lags between 11 and 17.

break date, and ξ_{yt}, ξ_{pt} are innovations with a mean of zero and a covariance matrix Σ_ξ. The test statistics (likelihood ratio statistics, LR statistics) are then:

$$(T - 2(n+1))(\log|\Sigma_e| - \log|\Sigma_\xi|), \tag{14}$$

where T is the number of observations. Under the null hypothesis, $b_1 = 0, b_2 = 0$ and $b_{ij}(k) = 0$ for all $i, j = 1, 2$ and $k = 1, \cdots, n$ (thus, no structural change), and the test statistic is asymptotically chi-squared with degrees of freedom equal to $2(n+1)$.

Table 2 shows the stability test results of our reduced-form VAR system (1) reporting chi-squared statistics. Possible break dates are set every January for the period of 1989–1996. In this table, we detect significant rejection results in 1989–1994. This shows that the parameter values in our VAR system shifted likely during or after the bubble economy. Also, in Figure 3, we find that the LR statistics are maximized at about 1992. So, in the rest of this paper, we use two selective subsample periods: February 1978–December 1991 and January 1992–December 2006.[12]

3.2 Structural Parameters Estimation for the AD-AS Model

This subsection divides the sample periods into two based on the result of the structural stability test in the previous subsection, and compares the estimated structural parameters between the two subsamples (February 1978–December 1991 and January 1992–December 2006) to see if any noticeable differences are detected.

The first and second rows of Table 3 present the estimates of the structural parameters along with their bootstrapped 90% confidence intervals for the period February 1978–December 1991, and January 1992–December 2006, respectively. The point estimate of α, the slope of the short-run AS curve, is 2.64 for the former subsample, and 3.35 for the latter subsample, although its estimate for both periods is not significantly different from zero.[13] Though the point estimates of α seem to have changed between two subsamples, its change may not be statistically significant because the confidence intervals are very

[12] Andrews (1993) and Hansen (1996) propose the test statistics of the 'sup' form in testing for structural change with the unknown change point. Alternatively, the estimation results with a break point at 1990, 1991, or 1993 are generally similar to the results obtained in the following subsection.

[13] The confidence interval for this estimate is very large. This may imply that the test of a parameter based on the $a_{22}(1)$ and $a_{12}(1)$ has a significance level greater than or equal to maximum power, as Faust and Leeper (1997) point out.

large. In addition, from (5), the immediate effect of an AD shock on output $\alpha/(1+\alpha)$ is 0.73 for the former subsample, and 0.77 for the latter subsample. We find that there is little change in the immediate effect of a demand shock on output. We also find that for the variance of AS or AD shocks, there is really not much difference between the former subsample and the latter subsample (the estimated variance of AS shocks σ_{ϵ}^2 is 1.82 for the former period, 2.12 for the latter period, and the estimated variance of AD shocks σ_{η}^2 is 1.34 for the former period, 1.70 for the latter period). Although some economists, e.g. Lucas (1973) and Ball et al. (1988), claim the slope of an AS curve depends on the volatility of AD, neither has the volatility been changed substantially. These results imply that, in contrast with Nishizaki and Watanabe (2000), there is little evidence that the Japanese short-run AS curve has been flattened since 1990s.

More importantly, the covariance between the shocks $\sigma_{\epsilon\eta}$ is 0.88 for the former period, and 1.58, which is statistically significant, for the latter period. This result means that the AD and AS curves tend to shift together in the same direction. Moreover, the correlation coefficient between the shocks $(\sigma_{\epsilon\eta}/(\sigma_{\epsilon} \times \sigma_{\eta}))$ rises from 0.52 to 0.82. This suggests that the extent to which AD and AS curves shifts in the same direction has been much stronger since 1992.

It is also interesting to examine the historical pattern of the AS and AD shocks. To this end, using the identified structural disturbances $\Delta\hat{\epsilon}, \Delta\hat{\eta}$, we calculate the estimated AS and AD shocks $\hat{\epsilon}, \hat{\eta}$ by accumulating these disturbances, that is, $\hat{\epsilon}_t = \sum_{s=1}^{t} \Delta\hat{\epsilon}_s, \hat{\eta}_t = \sum_{s=1}^{t} \Delta\hat{\eta}_s$. Figure 4 displays the estimated AS shocks ϵ_t (the solid line) and AD shocks η_t (the dotted line) over the period 1980–2005. For convenience we include shaded regions, which begin at an Economic and Social Research Institute (ESRI) business cycle peak, and end at a trough.

In describing our results, the estimated AD and AS shocks satisfactorily explain the historical pattern of the Japanese business cycle fluctuations. In particular, we find that in the recession phase (June 1985–November 1986, February 1991–October 1993, May 1997–January 1999, October 2000–January 2002), both AD shocks and AS shocks tended to fall. We also find that the estimated AS shocks persistently decreased after peaking in about 1989. This result implies that AS curves tended to shift persistently to the left for the long stagnation of the Japanese economy since the early 1990s. This is consistent with some studies which argue that Japan's productivity growth has dropped since the 1990s, such as Hayashi and Prescott (2002), Caballero et al. (2006) and Kawamoto (2005).[14] On the other hand, the estimated AD shocks are cyclical relative to the estimated AS shocks.[15]

3.3 Dynamic Effects of AD and AS shocks on Output and Price

This subsection analyses the dynamic effects of AD and AS shocks on output and prices by constructing the impulse responses. In order to obtain the impulse responses, we consider the case that an AD shock causes an AS curve as well as an AD curve to contemporaneously shift, and examine the dynamic effects of AD and 'exogenous' AS shocks.[16]

Figures 5 and 6 show the impulse responses of output and prices due to a 1% demand shock η_t and a 1% 'exogenous' supply shock δ_t for the former subsample of February 1978–December 1991 and latter subsample of January 1978–December 2006, respectively. The solid line indicates the estimated response. The estimated impulse responses are constructed in levels (i.e., cumulative responses) up to 60 months. The upper and lower dashed lines plotted in each graph represent 90 percent bootstrap confidence intervals based on 10000 bootstrap samples.

Overall, estimated impulse responses of output and prices due to a demand shock and an 'exogenous' supply shock are consistent with the textbook AD-AS theory. The top charts of Figures 5 and 6 show that a positive 'exogenous' supply shock causes output to increase, and prices to decrease. On the other hand, the bottom charts of Figures 5 and 6 show that a positive demand shock causes output to increase, and prices to increase.

However, comparing both figures, we detect a remarkable change in the estimated

[14]Hayashi and Prescott (2002) find that the total factor productivity (TFP) growth measured as the Solow residuals is decelerated substantially in the 1990s, and interpret such movements in TFP as the result of exogenous technology shocks. Caballero et al. (2006) attempt to attribute the low productivity to the misallocation of bank credit. Kawamoto (2005) says 'Japan's productivity slowdown in the 1990s appears to be a stylized fact', but concludes that the productivity slowdown observed in the 1990s is not a slowdown in the rate of technological progress by constructing the Solow residuals, which are purified for controlling for increasing returns, imperfect competition, varying utilization of capital and labor, and reallocation effects.

[15]There is no reason why the natural rate of output (the equilibrium level in the case of flexible prices) coincides with the efficient level of output (the equilibrium level in the case that there is no distortion as a result of taxes and market power etc). As Kuttner and Posen (2001) point out, the negative output gap, which is defined as a deviation from the efficient level of output, may have become much bigger since the 1990s.

[16]We confirm that the estimated 'exogenous' AS shocks $\hat{\delta}_t$ are not cyclical, although estimated AS shocks $\hat{\epsilon}_t$ are highly pro-cyclical as shown in Figure 4.

responses between the two subsamples, especially to a demand shock. The top-left charts of Figures 5 and 6 show that the dynamic response of output due to an 'exogenous' supply shock grows for around 3 years, then stabilizes at a permanently higher level, while the top-right charts of Figures 5 and 6 show that the dynamic response of prices due to an 'exogenous' supply shock falls for around 3 years, then stabilizes at a permanently lower level. This result implies that an 'exogenous' AS shock, which has long-run effects on output and prices, causes the long-run AS curve to slowly shift to the right. This property looks relatively similar in the former and latter sample. Note that the peak response of output is about 3.5 and 5 times the initial effect for the former subsample and the latter subsample, respectively, while the peak response of prices is about 2 and 1.5 times the initial effect for the former subsample and the latter subsample, respectively.

The bottom-left charts of Figures 5 and 6 show that the dynamic response of output due to a demand shock are long-lasting, despite the Blanchard and Quah (1989) restriction that a demand shock has no long-run effect on the level output. Although the long-run effect is insignificant for the former subsample, its effect is significant for the latter period. This result implies that a shift of AS endogenously arises due to an AD shock, and this effect is stronger for the latter period. In addition, the output response with the former subsample remains to be the initial effect until about 1 year, and slowly diminishes up to around 3 years. On the other hand, the output responses with the latter subsample peak at the 1 year (the peak response is about 1.5 times the initial effect), and are long-lasting with slight reductions up to around 3 years. This result implies that, for the latter subsample, both AD and endogenous AS shifts have an amplified effect on output in the short-run and a significant effect on output in the long-run.

The bottom-right charts of Figures 5 and 6 show that a demand shock has a significant effect on prices in the former subsample, while a demand shock has fairly limited effect on prices in the latter subsample. This result implies that both AD and endogenous AS shifts have limited effects on prices in the short-run and the long-run for the latter subsample.

To interpret intuitively the results we obtained, the effects of AD and AS shifts together in the same direction are shown in Figure 4, which describes the downward-sloping AD curve and the upward-sloping AS curve in output-price space. By a positive AD shock, the AD curve immediately shifts from AD to AD'. About 1 year after a shock arose, prices start to rise, and then output reaches the intersection of AD' with the short-run AS curve $SR\text{-}AS'$, not back to its previous level, over about 3 years. This is because a demand shock η_t causes the long-run AS curve to rise from $LR\text{-}AS$ to $LR\text{-}AS'$ through the endogenous technology progress (10), and then output converges to its new natural rate level. As demonstrated in Figure 4, these two shifts lead to larger and permanent effects on output but to limited effects on prices in the short-run and the long-run.[17]

4 Concluding Remarks

For the empirical fact that Japanese inflation is relatively stable with slight declines since the 1990s while output remains highly volatile as before, this paper seeks to understand the dynamics of Japanese output and prices especially since the 1990s. First, we provide that there is ample evidence for structural change in output and price dynamics since the beginning of the 1990s. Next, following Cover et al. (2006), we estimate the VAR model that allows for correlations between structural disturbances under the AD-AS framework, for the two subsamples: February 1978–December 1991 and January 1992–December 2006. In employing this approach, we can estimate the slope of the AS curve in the context of a new classical-type model, the variances of structural demand and supply shocks, and the extent to which structural demand and supply shocks are correlated. Moreover, we analyze the dynamic effects of the AD and AS shifts on output and prices.

There are three main findings. First, compared to the possibility of intensifying AD-AS interaction, there is less evidence that the Japanese short-run AS curve has been flattened since the 1990s. Second, the positive correlations between the demand and supply shocks have been stronger since the 1990s. Third, in the 1990s, shifts in AD and AS curves in the same direction led to larger and permanent effects on output and limited effects on prices.

There are a large number of studies which analyzed the cause of the prolonged slow-

[17] We can estimate the impulse responses on the assumption that an AS shock causes the AD curve to shift. This result is available on request. Note that in this case, as Cover et al. (2006) show, the impulse responses to an 'exogenous' AD and AS shock are mathematically equivalent to those to an AD or AS shock constructed by the standard Blanchard and Quah (1989) model. For the latter period, the output responses to a supply shock look quite similar to the output responses to a demand shock in Figure 6. This should not be surprising because these two responses arise due to unexpected changes in both AD and AS involved of a nearly identical size, as we find that demand and supply shocks are highly positively correlated over the latter period.

down of the Japanese economy since the 1990s. Kuttner and Posen (2001), Bayoumi (2001), and Horioka (2006) emphasize the importance of demand side factors. On the other hand, Hayashi and Prescott (2002), Caballero et al. (2006), and Kobayashi and Inaba (2006) emphasize the importance of supply side factors. The purpose of this paper is not to settle the question of whether demand side factors or supply side factors are more important. A novel contribution in this paper is to stress the role of correlation between both demand side and supply side factors, not just either of them. Some empirical results in this paper suggest that the strong correlation between them is the key to understanding the business cycle fluctuations behind the Japanese economy since the 1990s.

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Table 1: CPI Inflation Rate and IIP Growth Rate

		Mean	Std. Dev.	Range	Min	Max
IIP Growth	1978:2–1991:12	0.25	1.41	7.47	-3.36	4.11
(MONTHLY)	1992:1–2006:12	0.10	1.34	8.53	-4.38	4.15
CPI Inflation	1978:2–1991:12	0.21	0.35	2.06	-1.07	1.32
(MONTHLY)	1992:1–2006:12	0.00	0.19	1.27	-0.55	0.72

Table 2: Stability Test Results

Break Point		Break Point	
January, 1989	61.45^{*}	January, 1993	69.68^{**}
January, 1990	69.55^{**}	January, 1994	58.07^{*}
January, 1991	67.18^{**}	January, 1995	54.78
January, 1992	70.27^{**}	January, 1996	40.79

Note. This table reports chi-squared statistics testing for the structural stability of the reduced form dynamic systems. $**$ and $*$ denote rejections of the null by the 1% and 5% significance levels, respectively.

Table 3: Point Estimates of Structural Parameters of AD-AS Model

Period	α	σ_ϵ^2	σ_η^2	$\sigma_{\epsilon\eta}$	σ_δ^2	γ
February,1978–	2.64	1.82	1.34	0.88	1.43	0.66
December,1991	(-0.30, 8.86)	(0.94, 9.36)	(0.90, 1.39)	(-0.09, 1.12)	(0.06, 14.33)	(-0.09, 0.93)
January,1992–	3.35	2.12	1.70	1.58	0.86	0.93
December,2006	(-0.62,9.28)	(1.30, 4.31)	(1.20, 1.79)	(1.05, 1.74)	(0.02, 3.07)	(0.80, 1.01)

Figures in parentheses are 90% confidence intervals from bootstraping. α is sensitivity of AS to an unexpected change in inflation. σ_ϵ^2 is variance of total AS shock. σ_η^2 is variance of total structural AD shock. $\sigma_{\epsilon\eta}^2$ is covariance between total structural shocks to AS and AD. σ_δ^2 is variance of 'exogenous' AS shock. γ is effect of shock to AD on total shock to AS.

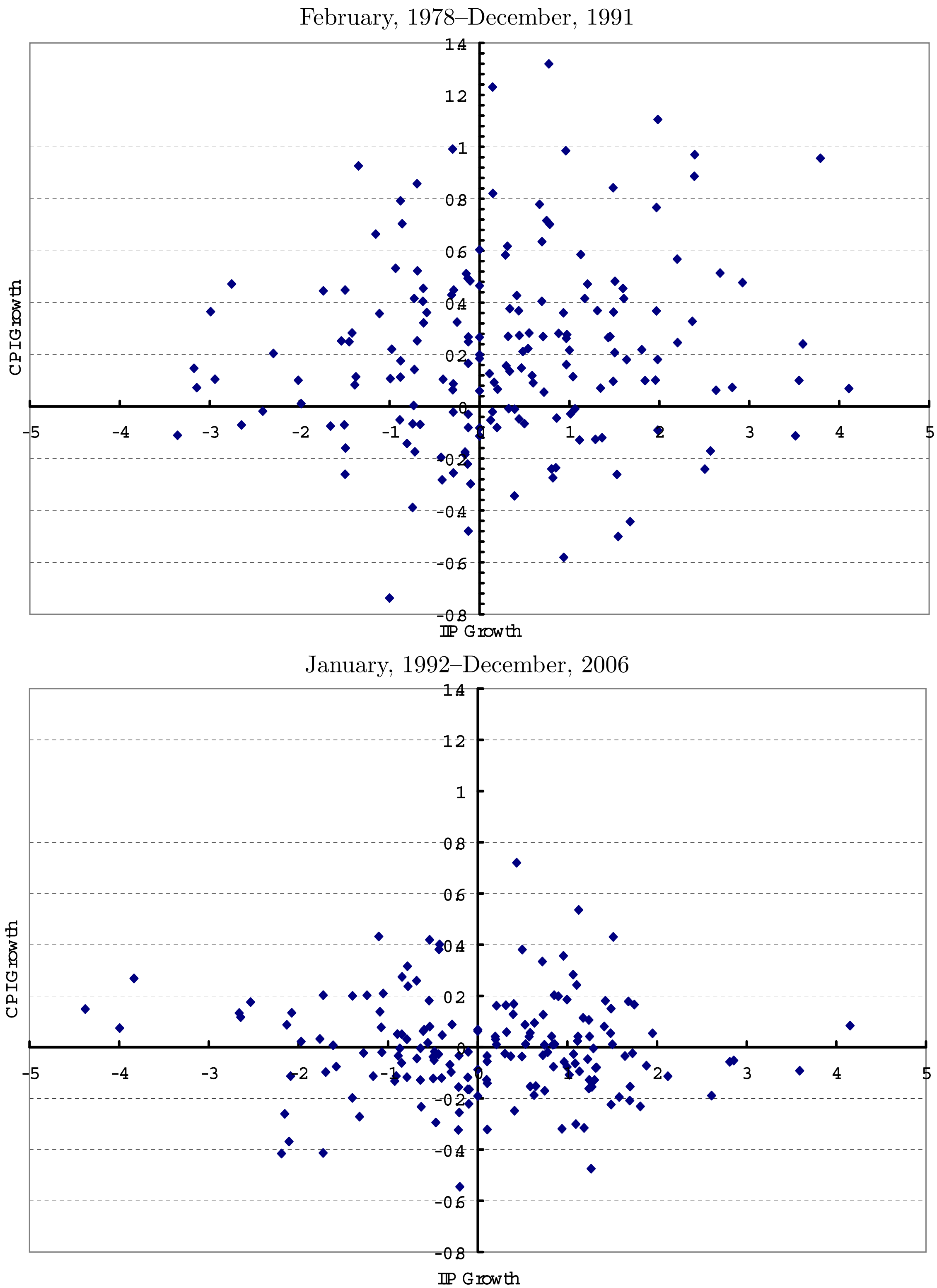

Figure 1: Scatter Plot: IIP Growth (horizontal axis, %) and Inflation (vertical axis, %): February, 1978–December, 1991 (upper panel); January, 1992–December, 2006 (lower panel)

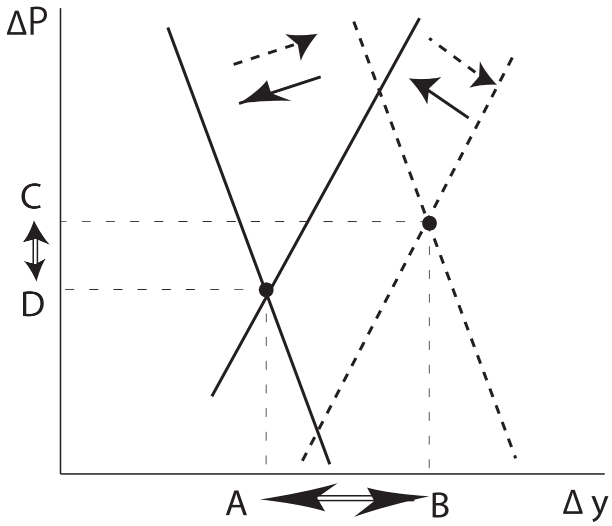

Figure 2: The AD-AS model in output growth-inflation space: The positive correlation between the AD and AS curve shifts.

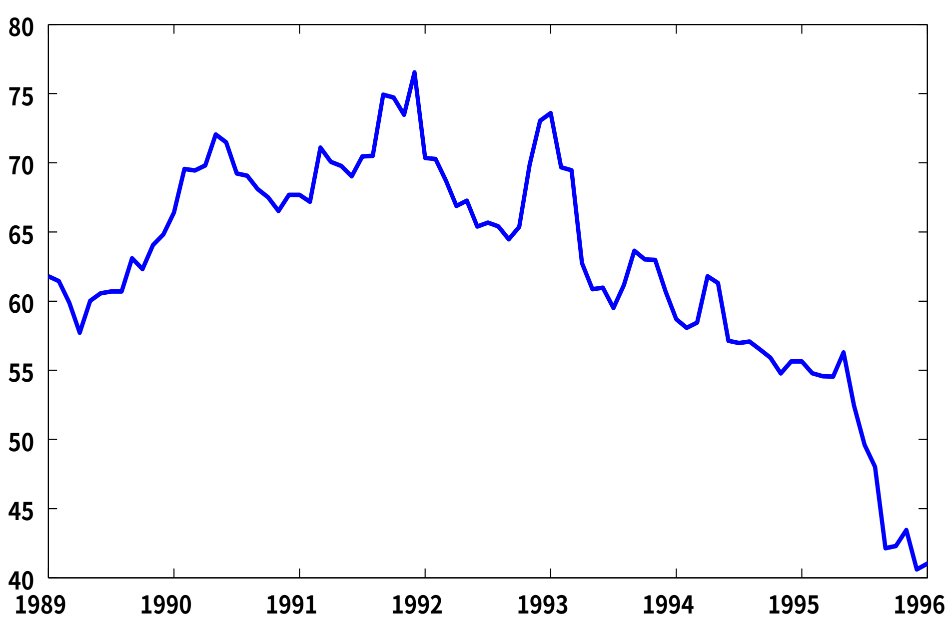

Figure 3: Likelihood Ratio Statistics for the Structural Change.

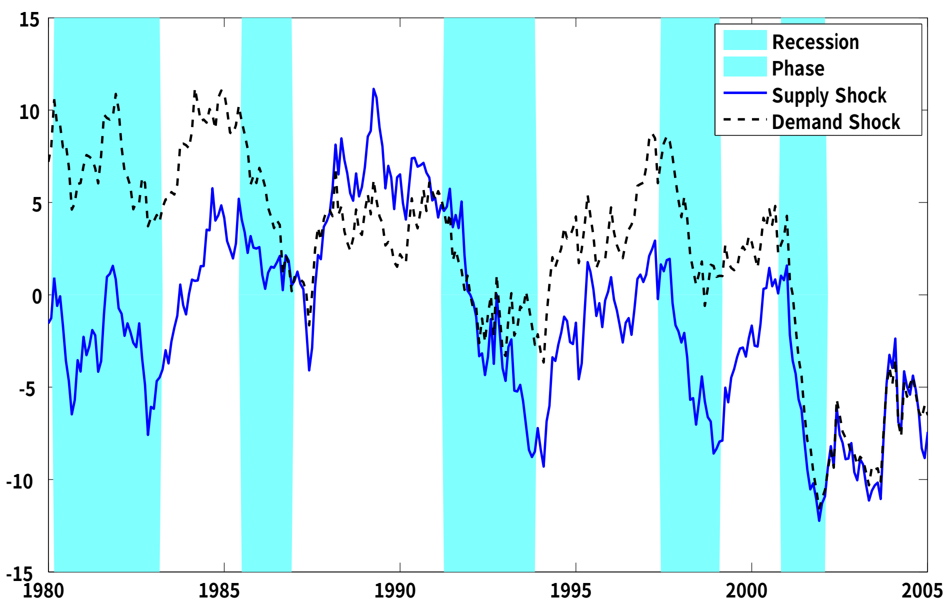

Figure 4: Estimated AS Shocks $\hat{\epsilon}_t$ and AD shocks $\hat{\eta}_t$

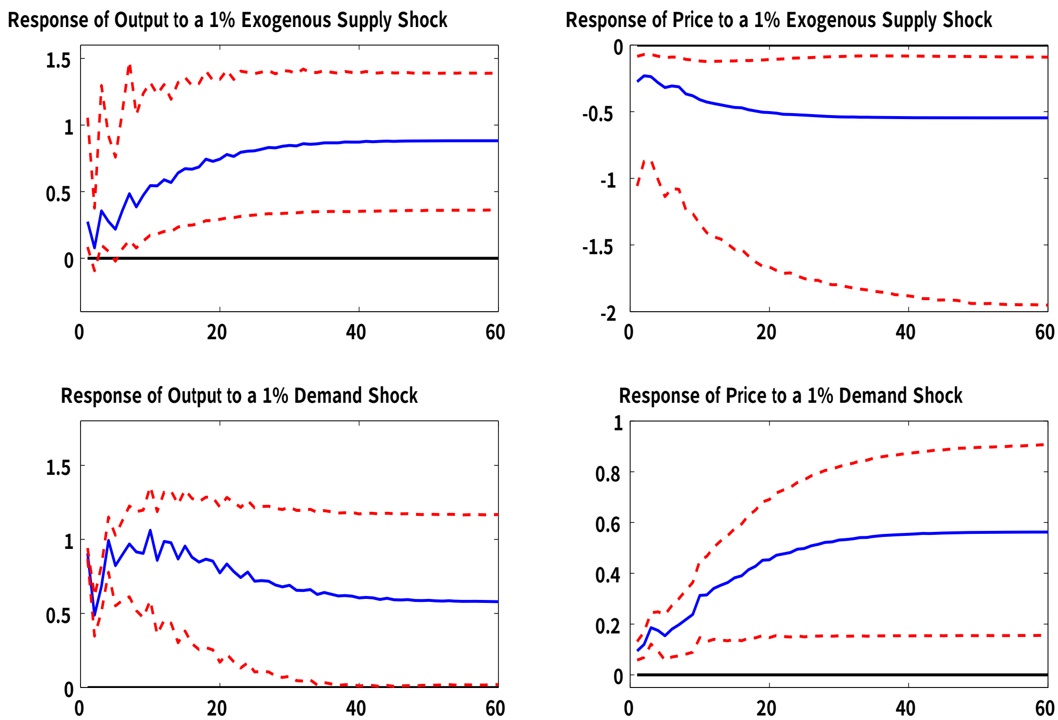

Figure 5: Impulse Responses (February,1978–December,1991)

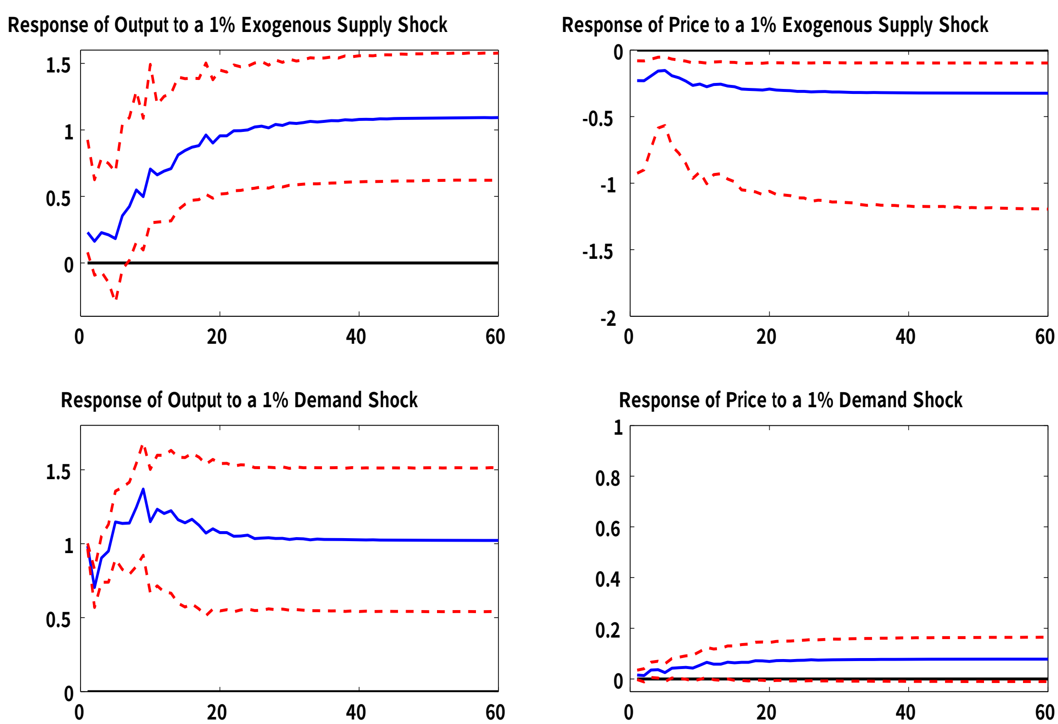

Figure 6: Impulse Responses (January,1992–December,2006)

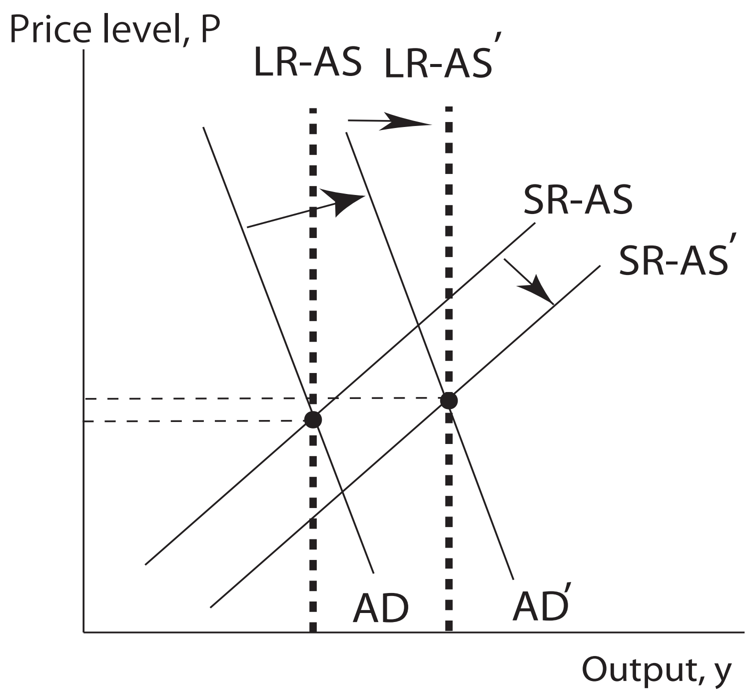

Figure 7: Dynamic Effects of Both an AD shift and an AS shift on Output and Prices