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Inflation Dynamics in China

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Abstract

This paper comprehensively investigates inflation dynamics in China. First, we estimate a structural vector autoregression to verify the 'consensus view' of inflation dynamics in China. We provide the results of basic empirical analyses on inflation mechanisms in China. In the context of the relationship between the output gap and the conventional Phillips curve, we find that the output gap proxied by electricity consumption per unit of capital is a better measure of inflation pressure than another alternative. Based on our analysis of the relationship between input and output prices, we show that wage growth is a substantial determinant of inflation. The estimation of the long-run equilibrium relationship between money, output and prices clearly indicates that the money gap (i.e., the gap between the actual and long-run equilibrium levels of money) Granger-causes consumer price inflation. Based on these empirical results, we assess current inflation and the outlook for inflation in China and draw policy implications.

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Nontechnical Summary

This paper comprehensively investigates inflation dynamics and mechanisms in China since 'economic reform and open policies' began in 1978. Section 1 clarifies the purpose and organization of this paper. Sections 2 and 3 provide an overview of inflation dynamics in China. Sections 4, 5 and 6 present empirical analyses of inflation mechanisms and consider the implications of this study and directions for future research.

Section 2 surveys the related literature on inflation in China. Section 3 provides a historical decomposition of the inflation rate to provide an overview of inflation dynamics since 1978. China experienced inflation upsurges four times, and inflation peaked in 1980, 1985, 1988 and 1994. We identify two major factors behind these inflation upsurges. The first is the influence of price adjustment and liberalization. When authorities implemented adjustments and reductions in administered prices, inflationary pressures surged since most administered prices were lower than the market clearing price levels. The adjustments and reductions in administered prices also fueled inflation by generating speculative buying and causing opportunistic price increases in consumer goods. The second factor is the 'soft budget constraints' of state-owned enterprises (SOEs). The SOEs borrowed heavily from the state-owned banks to finance inefficiently large fixed investments and extreme wage increases, thereby accelerating monetary growth.

Since 1997, the Chinese economy has not experienced hyperinflation but has experienced two episodes of deflation, which are negative annual changes in the consumer price index (CPI). These occurred between 1998 and 1999 and from the end of 2001 to the end of 2002. During these periods, two factors contributed to preventing an inflation upsurge. The first was the price liberalization, which had been completed in the mid-1990s. The second was the full-scale reform of SOEs, which 'hardened' budget constrains. In the deflation period of 1998-1999, the main cause of deflation, according to our results, was a negative demand shock. This was due to the capital crunch (the banks' reluctance to grant or increase loans) and the fall in household income due to the reform of SOEs. We find that the increase in supply capacity and the fall in raw-material prices were the main contributors to the deflation that occurred between the end of 2001

and the end of 2002.

The next three sections present empirical studies of inflation mechanisms. In section 4, we measure the output gap, which is the ratio of actual output to potential output. Then, we estimate the conventional Phillips curve in order to investigate the statistical relationship between real-economy fluctuations and the inflation rate. We use two measures of the output gap. One is the 'orthodox' output gap, which is based on the detrended Solow residual from the production function. The other, referred to as the 'electricity output gap', uses electricity data to measure the output gap. This measure was originally proposed by Kamada and Masuda (2000) in their study of Japan's output gap. The electricity output gap regards the cyclical component of electricity consumption per unit of capital as the capital utilization ratio. A comparison of the two output gaps reveals that the electricity output gap is better than the orthodox measure as the proxy of inflationary pressure. Based on the estimated Phillips curve, we point out that the economy overheated in the inflation upsurge periods of 1988 and 1994. We also show that the output gap has been around zero since mid-2002, while the economy was in recession in the deflation period of 1998-1999.

Output-price inflation is also affected by the dynamics of input prices. Section 5 analyzes the relationship between input and output prices. Our main findings are as follows. (1) There is a general tendency for inflation rates to rise with wage increases. (2) The growth rate of real wages was higher than that of labor productivity before 1997, but productivity growth exceeded wage growth from 1998. This suggests that relatively low real-wage growth reduced labor costs and contributed to low inflation after the mid-1990s. (3) The CPI inflation rate is positively correlated to inflation rates for prices of raw material and intermediate goods. Therefore, the recent increases in raw-material prices and intermediate-good prices have put potential upward pressure on consumer price inflation.

In Section 6, we discuss the empirical relationship between money (M2), output (real GDP) and prices (the CPI) to complement the previous two sections, in which we focused on the short-run effects of real-economy fluctuations on inflation. We find a stable long-run equilibrium relationship between these three variables. More precisely, the money gap, which is the gap between actual M2 and its equilibrium level relative to

output and prices statistically significantly forecast future inflation. That is, money precedes inflation (or money 'Granger-causes' inflation).

Section 7 concludes the paper. Based on the decomposition of inflation and the output gaps, we conclude that the Chinese economy has been neutral to inflationary pressure at the end of 2004. Given this finding and given our focus on aggregate data, we evaluate that the Chinese authorities have controlled the economy well. We also point out that upward pressure on real wages and the recent increase in raw-material prices and intermediate-good prices may produce inflationary pressure on consumer prices in the future. The transition to a market economy in China seems to have strengthened the flexibility of the economy and the transmission mechanism for monetary policy through interest rates. Finally, we briefly discuss directions for future research.

1. Introduction

China has experienced impressive economic performance since late 2003 when the economy started to recover from the downturn caused by an outbreak of SARS. Fixed investment largely increased output growth. The growth rate of real GDP has been more than 8 percent (per year). Monetary aggregates (such as M2) and the amount of renminbi bank loans increase by around 15 percent annually. Some people consider these figures to be the evidence of economic overheating. On the other hand, CPI inflation remains low and stable. It reached its recent peak of 5.3 percent in July and August 2004, which is low historically in the context of high-growth periods. Historically, it has been rare in China for high output growth to accompany low inflation. Therefore, it is difficult to judge the extent of economic overheating in China in this period.

The purpose of this paper is to improve understanding of China's economy by empirically analyzing inflation dynamics in China. Much literature qualitatively discuses the mechanism behind business cycles in China. By contrast, little empirical work has been done on China's economy.[1] Several factors explain this paucity of empirical work. (1) There is limited availability of economic statistics in China. (2) The quality of the statistics may be dubious.[2] (3) Structural changes in the economic system and economic policies are difficult to control for. However, recently, data availability has increased. Some economists insist that statistics in China are reliable enough for basic quantitative analysis.[3] Furthermore, it is difficult to disregard the official statistics from the viewpoint of practitioners in economic research on China. Therefore, we use the official statistics released by the Chinese authorities for our empirical analysis of inflation.

The remainder of this paper is structured as follows. In Section 2, we present an overview of inflation development since 1978, when 'economic reform and open policies' began. In Section 3, we decompose the inflation rate into fundamental shocks by using a structural vector autoregression (SVAR) to identify the causes of inflationary

[1] Notable exceptions are Gerlach and Peng (2004), Ha et al. (2003), Oppers (1997) and Zhong (1998).
[2] For example, Young (2003) argues that real GDP growth in the nonagricultural sector from 1978 to 1998 has been overestimated by around 2.5 percent because of an underestimation of the GDP deflator.
[3] For example, Professor Gregory Chow (of Princeton University) concludes in Chow (1993) that "I have found Chinese statistics, by and large, to be internally consistent and accurate enough for empirical work."

and deflationary episodes. In Section 4, we measure the output gap and estimate the conventional Phillips curve to quantify the relationship between the output gap and the inflation rate. In Section 5, we analyze the relationship between the CPI and factor (input) prices such as labor costs and raw-material prices. In Section 6, we focus on the long-run relationship between money, output and prices. In Section 7, we provide concluding remarks.

2. Overview of Inflation Development in China

In 2004, China experienced the favorable combination of high growth (an annual growth rate of real GDP of 9.5 percent) and low inflation (given an annual CPI inflation rate of 3.9 percent). This is a rather unusual combination in the context of China's history.[4] From 1978, the first year of 'economic reform and open policies', to the mid-1990s, several episodes of pronounced upswings of growth and inflation were followed by short-lived episodes of relatively low growth and low inflation (Chart 1). The Retail Price Index (RPI) indicates four inflation cycles, in which inflation peaked in 1980, 1985, 1988 and 1994.[5] However, since 1997, when the Chinese authorities introduced market mechanisms in earnest, China experienced deflation (negative annual growth in the CPI) twice, from 1998 to 1999 and from the end of 2001 to the end of 2002. At the same time, the real growth rate fluctuated only between 7 and 9 percent. In this section, we review these inflation and deflation episodes by conducting a literature survey.

2-1. Mechanisms behind the Inflation Upsurge in the Planned Economy

The literature points out the following two factors as the main causes of the inflation upsurge from 1978 to the mid-1990s. One is the effect of price adjustment and liberalization. The other is the expansionary expenditure of local governments and SOEs.

[4] The People's Bank of China (2005) has included a column to review inflation dynamics since 1978.
[5] Since CPI data are only available from 1985, we use RPI data as a proxy for the CPI, following Brandt and Zhu (2000) and Oppers (1997).

2-1-1. Impacts of Price Adjustment and Liberalization

According to Oppers (1997), the following two elements led to an acceleration of inflation until it peaked in 1980. (1) Price controls were adjusted. (2) Limited economic reforms were implemented that allowed SOEs to determine some of their own expenditures. Price adjustment included a large increase in the administered price of agricultural procurements and the limited introduction of 'guided prices'.[6] These reforms led to a sharp increase in aggregate demand because farmers' incomes rose markedly and SOEs increased investment and wages. Consequently, annual RPI inflation increased from 1 percent in 1978 to 6 percent in 1980.

Price adjustment and liberalization had been expedited since the mid-1980s by the so-called 'two-track pricing system', comprising administered prices, guided prices and market prices. The introduction of market prices caused the prices of daily necessities to surge and led to an acceleration of RPI inflation in the late 1980s as well as economic overheating. In April 1988, the authorities implemented a major adjustment in the administered prices of foods. This led to expectations of further price increases and speculative buying of durable goods, thereby adding to the strong growth in aggregate demand. Given an inflation upsurge, further price adjustment and liberalization were tentatively postponed. In the early 1990s, however, price adjustment and liberalization accelerated. As a result, most goods on the market have been traded at market prices since the late 1990s.[7] Table 1 clearly indicates a fall in the share of administered prices and guided prices for retail goods and agricultural products in 1985, 1988 and 1992.

As Gerlach and Peng (2004) pointed out, price adjustment and liberalization are likely to lead initially to a sharp increase in inflation by causing prices to adjust toward market-clearing levels and by leading to speculative buying. Prices decline in the long run as competition in the deregulated market leads to a more efficient allocation of resources and lower profit margins.

[6] Administered prices are controlled by the central or provincial authorities. Guided Prices fluctuate within a band set by the authorities.
[7] As Oppers (1997) points out, 'market prices' are not necessarily fully determined by the market, because there has been intervention in the form of price management and indirect controls.

2-1-2. Rising Expenditures of Local Governments and SOEs

Much previous work suggests that the rising expenditure of local authorities and SOEs during the process of decentralization was one of the main contributors to business cycles in China. For example, greater autonomy for SOEs in setting wages and allocating social funds is thought to have been one of the main causes of the economic overheating and inflation upsurges of 1985 and 1988 because it led to large wage increases and inefficiently large fixed investments.

The soft budget constraints of publicly owned enterprises account for inflation upsurges driven by excessive fixed investment by local authorities and SOEs.[8] Fan (2003) explains that a company faces a soft budget constraint if it cannot go bankrupt because of *ex post* compensation by the authorities (or state-owned banks). A soft budget constraint induces local authorities and SOEs to expand their expenditure as much as possible. Therefore, once restrictions on liquidity and fixed investments are relaxed, local authorities and SOEs compete to expand their expenditures, and this generates inflationary pressures.

Brandt and Zhu (2000, 2001) explain how soft budget constraints accelerate inflation as follows. When credit allocation is decentralized from the central government to local governments, state-owned banks can divert loans from inefficient SOEs to the more productive non-state sector. While this diversion increases fixed investment and production in the non-state sector, the share of SOEs in total output declines. However, since governments commit to the investment and employment of SOEs, governments must transfer funds to SOEs. They provide funds in the form of cheap credit from the state-owned bank and money creation to finance wage payments, capital expenditures and other costs.[9] Local governments that are responsible for promoting local economic growth also force local branches of the central bank to expand their loans to state-owned banks.[10] Hence, actual credit exceeds the credit level set by the central government. The

[8] Zhong (1998, 2003) surveys the models to explain the relationship between the expenditures of local governments and SOEs and business cycles.
[9] Consequently, the gap between the output contribution of the SOEs and their shares of employment and investment increased.
[10] Ma (1995) explains why local branch offices of the central bank are controlled by local governments. One reason is that the central bank is not allowed to nominate a branch manager without local government consent. Another is that executive promotions are based on contributions to local economic growth.

central bank relies increasingly on money creation to finance increasing transfers.[11] Consequently, aggregate demand increases, there is overheating, and inflation accelerates. In other words, when SOEs have soft budget constraints, China's economy booms because quantitative controls on investment and credit are relaxed.

In Chart 2, we illustrate trends in seigniorage, money (M2) and the CPI.[12] Seigniorage tends to precede money and inflation until the mid-1990s. This observation is consistent with the mechanism described above.

We summarize the previous arguments as follows. The two factors that caused the inflation upsurges of 1980, 1985, 1988 and 1994 were: (1) price adjustment and liberalization, which generated a negative supply shock in the short run; and (2) money creation due to the soft budget constraints of SOEs, which generated a positive demand shock.

2-2. Determinants of Inflation in the Transition to a Market Economy

China's economy has had no inflation upsurges since 1995 but has experienced deflation twice: once from 1998 to 1999, and again from the end of 2001 to the end of 2002. The transition to a market economy affects the inflation mechanism. The reform of SOEs started in the 1970s but accelerated from late 1996. The reform was equivalent to a reduced commitment by central government to SOEs, and it hardened the budget constraints of SOEs. This made it harder to finance rising state-sector expenditure by printing money. Market forces weeded out inefficient SOEs to normalize the balance of aggregate demand and supply in China's economy. At the same time, state-owned banks were reformed to reduce and restrain nonperforming loans. This blocked the mechanism of amplifying inefficient credit growth. As a result, it became somewhat easier for authorities to avoid economic overheating.

The hardening of SOEs' budget constraints reduced inflation but did not necessarily cause deflation. Fan (2003) insists that the capital crunch (banks' reluctance

[11] Brandt and Zhu (2000) estimate that more than 3 percent of GNP was transferred annually to SOEs to support their management in 1993.
[12] Seigniorage and money are calculated as annual increases in M0 and M2 (as shares of nominal GDP, detrended) following Brandt and Zhu (2000).

to grant or expand loans) reduced aggregate demand growth and caused deflation at the end of the 1990s. In fact, the growth of bank credit slowed from late 1996 to late 2002 (Chart 3). By contrast, Fan (2003) and Feyzioglu (2004) attribute the deflation from the end of 2001 to 2002 to improvements in economic efficiency and the rise in factor productivity. We measure the growth of labor productivity as the growth of per capita real output (Chart 4). The fact that the growth rate of per capita GDP has risen since 1998 indicates the existence of positive supply shocks. In addition, Feyzioglu (2004) points to the decline in raw-material prices and the reduction in tariff rates as common features of the two deflationary periods.

Chart 5 shows the decomposition of annual CPI inflation into its components. We assume that the component weights of the CPI after 2001, the year of major statistical revision, are the same as those of 2004, while weights for years before 2000 are set equal to 1995 weights. We identify the following characteristics.

(1) The behavior of both the CPI, including and excluding foods, changed dramatically before and after 1997.

(2) Foods is the main contributor to CPI dynamics, since it has the largest weight in the components.

(3) Most components rose in 1994, which suggests the influence of a positive demand shock.

To summarize, the reform of state-owned enterprises contributed to dampening the positive demand shock. In other words, the main determinants of inflation dynamics changed in the mid-1990s. Thus, we investigate inflation mechanisms empirically in the following four sections.

3. Decomposition of Inflation Development based on a Structural VAR

In this section, we investigate the shocks driving inflation in China. For this purpose, we estimate a bivariate SVAR for the growth rates of real GDP and the CPI in order to decompose inflation dynamics since the late 1980s into two components, aggregate demand shocks and aggregate supply shocks.

For the identification of the model, we assume that an aggregate demand shock has no long-run impact on the level of output. Zhang (2003) applies this approach to Chinese data.[13] She begins by calculating real output by deflating monthly industrial production by the GDP deflator. Then, she estimates an SVAR on monthly data for real output and the RPI. She concludes that aggregate demand shocks primarily explain inflation in China. We estimate a quarterly SVAR for real GDP and CPI inflation by using data from 1987 and empirically examine the discussion of the previous section.[14]

We first check for unit roots and cointegration between real GDP and CPI to confirm that both time series follow I(1) processes and are not cointegrated. Then, we estimate a reduced form VAR comprising the first differences of the two variables.[15] We identify the parameters of the SVAR by imposing the long-run restriction that aggregate demand shocks have no long-run impact on output levels.[16]

Chart 6 presents identified cumulative impulse responses for real GDP and CPI. Both impulse responses for real GDP are compatible with the signs expected from economic theory. However, while economic theory predicts a negative long-run response of CPI to aggregate supply shocks, the impulse response changes from negative to positive four quarters after the shock. The variance decomposition in Table 2, however, indicates that aggregate demand shocks primarily explain inflation fluctuations: they explain 91.1 percent after four quarters and 69.6 percent after 36 quarters. This result implies that even if the long-run response of CPI to aggregate supply shocks is not of the expected sign, it would have a negligible impact in the context of the historical decomposition.[17]

Chart 7 depicts the contributions of aggregate demand and supply shocks to inflation. In the inflation cycle that peaked in 1994, demand shocks contribute to the rise

[13] Zhang (2003) refers to Liu and Zhang (2002, which is in Chinese and not available to the authors), who estimate an SVAR by using quarterly data. According to Zhang (2003), their work has the following shortcomings relating to the data used. (1) The data are accumulated from the beginning of the year. (2) Missing data on nominal GDP are replaced by data on industrial production.
[14] Data are from 1987Q1 to 2004Q4. Both real GDP and the CPI are seasonally adjusted on the basis of an X-12-ARIMA model.
[15] We set the lag length at three, *a priori*. The results are robust to changes in the lag length of the VAR.
[16] We estimated the model by indirect least squares.
[17] This argument follows Mio (2001).

in inflation. This feature coincides with the positive demand shock under soft budget constraints, in the form of the rising fixed investment and wage increases of SOEs and the accompanying increases in monetary aggregates. The component explained by the supply shock also increases from 1993 to 1994. This is consistent with the argument of the previous section that price adjustment and liberalization initially worked as a negative supply shock to rise inflation.

In marked contrast to the movement before 1996, the component explained by the demand shock does not increase significantly after 1997. This supports the hypothesis that the budget constraints of SOEs hardened following reforms to introduce the market mechanism in China from 1996. It is also clear that the driving forces behind the two deflationary episodes are qualitatively different. In the former period, from 1998 to 1999, the negative demand shock caused deflation. This coincides with the argument of Fan (2003) that the capital crunch was the main source of deflation. Another candidate for a negative demand shock is the wage reduction accompanied by the structural reform of SOEs. By contrast, the positive supply shock (reflecting the improvement in overall economic efficiency) drove the inflation rate below zero in the second deflationary period, from the end of 2001 to the end of 2002.

The preceding empirical results and the arguments of the previous section suggest the following. First, the determinants of inflation changed in 1996, when the reform of SOEs and state-owned banks began in earnest. Second, given that large increases in positive demand shocks are rare, the positive supply shock, in the form of increased capacity, has contributed the recent low levels of inflation. These results also imply that China's economy has been more market oriented recently. Hence, in the following three sections, we discuss three relationships that are important for the market economy. These are the relationship between the output gap and inflation, the relationship between input (factor) and output prices, and the long-run relationship between money, output and prices.

4. The Output Gap and the Conventional Phillips Curve

In this section, we measure the output gap, i.e., the gap between actual and

potential output, and investigate its influence on inflation. There are two broad approaches to measure output gaps. One is the production function approach. In this approach, one constructs a production function comprising capital, labor and total factor productivity (TFP). One can then estimate potential output as the average of those three factors.[18] An advantage of this approach is that it provides information on the sources of economic growth, while mismeasuring capital and labor may bias the estimated output gap.

Another approach is to estimate potential output from the trend in real GDP by using time-series techniques. While this approach avoids the effect of measurement errors in factors, the dynamics of potential output must be known *a priori*. This method also provides no information on growth mechanisms. Thus, it is often considered as a complement to the production function approach.

We first estimate and compare two output gaps with the production function approach by using annual data from 1978 to 2004. One is the orthodox output gap and the other is the electricity output gap, based on electricity data. This measure was originally proposed by Kamada and Masuda (2000) in their study of Japan's output gap. Then, we estimate the output gap by using time-series techniques with quarterly data from 1987Q1 to 2004Q4. Then, we review the development of inflation from the late 1980s based on these output gaps.

4-1. The Output Gap based on the Production Function Approach

4-1-1. The Orthodox Output Gap

We first estimate the orthodox output gap (gap^{orth}) by using the production function approach.

The first step is to set up a Cobb–Douglas production function comprising capital, labor, and TFP, following Chow (1993) and Chow and Li (2002):

$$Y = A \cdot L^{\alpha} \cdot \left(\gamma \cdot K\right)^{1-\alpha} \qquad (1)$$

[18] There are two definitions of potential output. One defines potential output as the maximum level of output that a country can produce. The other defines it as an average level of output. In this paper, we adopt the latter definition.

where Y is real output, A is TFP, L is labor input, K is capital stock, γ is the capital utilization ratio, the average of which is set to unity, and α is the labor contribution ratio. Under the assumption of perfect competition, α is equal to the labor distribution ratio. Taking logarithms of both sides of equation (1), we have the following.

$$\ln Y = \ln A + \alpha \ln L + (1-\alpha)\ln(\gamma \cdot K) \tag{2}$$

The Solow residual ($\ln \overline{A}$) is derived by subtracting the second and third terms on the right-hand side from the left-hand side of equation (2).

Potential output is the output level produced with the average amounts of labor, capital, and the capital utilization ratio (which is unity).

$$\ln Y^* = \ln A + \alpha \ln L^* + (1-\alpha)\ln K \tag{3}$$

The output gap is defined as the difference between actual and potential output. Equation (4) represents the basic definition of the output gap.

$$gap \cong \ln Y - \ln Y^* = \alpha(\ln L - \ln L^*) + (1-\alpha)\ln \gamma \tag{4}$$

Next, we describe the data used to estimate the output gap (see the Appendix for details). Y is real GDP and L is total employment. K is the capital stock, as originally estimated by Chow (1993) and extended by authors using the method of Chow and Li (2003). α is the average labor contribution from 1993 to 2003.[19]

The disadvantage of the production function approach is that the quality of the estimates depends heavily on data quality. There are no data in China that can be used to measure γ. Kamada and Masuda (2000) point out that even if data for γ contains measurement error, one can obtain unbiased estimates of TFP and the output gap by regressing $\ln \overline{A}$ on a linear time trend under two conditions. That is, $\ln \gamma$ must equal zero on average, and true TFP growth must be constant. Hence, we assume that TFP increases with a linear trend (i.e., $\ln A = \beta_1 + \beta_2 \cdot t$, so that $\ln \overline{A} = \beta_1 + \beta_2 \cdot t + e_1$) and that γ is fixed at unity.[20]

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[19] We obtain similar results when we use $\alpha = 0.60$, which is the average value of the labor contribution from 1978 to 1995 used in Young (2003).

[20] We have not seen the early studies on potential GDP or on the GDP gap in China in which the utilization of capital is adjusted.

It is questionable whether L^*, total employment, is an appropriate proxy for true labor input. According to Marukawa (2002), labor statistics in China may be dubious for two reasons. First, the coverage of unemployment is much more restrictive than the international standard. Second, employees who are laid off are not defined as unemployed. For example, the unemployment rate in China fluctuates little although real GDP growth suggests business cycles since 1978. Furthermore, the unemployment rate has been rather stable recently although unemployment in urban areas is being treated as a serious social problem. Thus, we suggest that, at best, data on total employment merely represent the trend in labor input but do not reflect precise fluctuations in labor input. In other words, total employment may measure labor input with error. According to Kamada and Masuda (2000), one can obtain unbiased estimates of TFP and the output gap by regressing $\ln \overline{A}$ on a linear time trend if the following two conditions are satisfied. First, $\ln L - \ln L^*$ is zero on average. Second, true TFP follows a linear time trend. Hence, we assume that $\ln L - \ln L^*$ is always zero and TFP follows a linear trend.

The assumptions of a linear time trend for TFP, a constant γ, and $L = L^*$ imply that the orthodox output gap is equivalent to the residual from a regression of $\ln \overline{A}$ on a linear time trend.

$$gap^{orth} \cong \ln Y - \ln Y^* = e_1 \qquad (5)$$

where $e_1 = \ln \overline{A} - \ln A$.

Chow (1993) assumes that TFP was constant before 1978, the first year of 'economic reform and open policies', and has since increased on a linear trend. Following Chow (1993), we assume the linear time trend is zero before 1978 and increases by one each year thereafter.

4-1-2. The Electricity Output Gap

In estimating the orthodox output gap, we controlled for the influence of fluctuations in capital utilization by assuming a linear trend for TFP. Here, we estimate the capital utilization ratio directly from electricity consumption data and incorporate this in measuring the output gap.

Statistics on electricity consumption and production are compiled by the central

government. Wang and Meng (2001) list the following conditions for the reliability of statistics in China. First, statistics should not be compiled by local governments because they have incentives to exaggerate the results of their economic policies. Second, statistics should not be deflated by price indices but should be measured in real terms. Electricity statistics satisfy these criteria.

Kamada and Masuda (2000) originally proposed measuring the capital utilization ratio by using electricity data in the context of measuring the output gap. Their basic idea is as follows. The trend component of electricity consumption per unit of capital is considered to be determined by industry structure and the technology embodied in capital. Thus, the cyclical component corresponds to capital utilization.

Following Kamada and Masuda (2000), we measure the output gap in China by using electricity data. We first calculate electricity consumption per unit of capital by dividing electricity production by the capital stock and assuming that this follows a linear trend.

$$ELEC/K = \mu_1 + \mu_2 \cdot t + e_2 \qquad (6)$$

where $ELEC$ is electricity production.

The first and second terms on right hand side of equation (6), $\mu_1 + \mu_2 \cdot t$, represents the electricity consumption per unit of capital corresponding to potential output. This decreases if the overall energy efficiency of the economy improves, while it increases when the proportion of high-energy-consuming industries increases. It also increases if electricity is substituted for coal and as household use of air conditioners spreads. In Chart 8, the electricity consumption per unit of capital, $ELEC/K$, levels off between 1970 and 1977, decreases since 1978, and bottoms out between 1999 and 2000. We assume two linear time trends to estimate γ^{elec}: t_1 is zero before 1978 and increases by one each year thereafter, and t_2 is zero before 2002 and increases by one each year thereafter.[21] We suppose that fluctuations in γ^{elec} reflect not only changes in capital utilization but also changes in labor intensity, because electricity consumption is expected to increase proportionally with labor intensity.

[21] We chose 2002 as the point for the trend break on the basis of a two-point grid search in which we set 2004 as the end point. We searched for the start point among the years between 1999 and 2003. See Kamada and Masuda (2000) for more details.

The capital utilization ratio measured by using data on electricity consumption, γ^{elec}, is formulated as follows.

$$\gamma^{elec} = (\mu_1 + e_2)/\mu_1 \tag{7}$$

If γ^{elec} and other variables contain no measurement errors, the Solow residual represents true TFP; i.e., $\ln \overline{A} = \ln A$. In this context, we again assume $L = L^*$. Under these assumptions, the output gap measured by using electricity consumption data, gap^{elec}, is equivalent to the second term of equation (4), i.e., the logarithm of γ^{elec} multiplied by the production elasticity of capital, $(1-\alpha)$.

$$gap^{elec} \cong \ln Y - \ln Y^* = (1-\alpha)\ln \gamma^{elec} \tag{8}$$

Combining equations (7) and (8) yields equation (9) below.

$$gap^{elec} \cong (1-\alpha)\ln((\mu_1 + e_2)/\mu_1) \tag{9}$$

Comparing equations (5) and (9) reveals the difference between gap^{orth} and gap^{elec}. The former is the cyclical component of the Solow residual, while gap^{elec} represents the cyclical component of electricity consumption per unit of capital. In addition, gap^{elec} does not depend directly on real GDP and employment. Therefore, gap^{elec} is a less biased estimator of the output gap if real GDP and employment are measured with more error than is electricity production.

4-1-3. Comparing the Orthodox and Electricity Output Gaps

In this subsection, we compare the two output gaps based on the production function approach: the orthodox output gap, gap^{orth}, and the electricity output gap, gap^{elec}. The comparison is based on the degree to which each is correlated with CPI inflation and the associated goodness of fit of the conventional Phillips curve.

Chart 9 compares the two output gaps and annual CPI inflation. Both gaps seem to fluctuate with the inflation rate. However, gap^{elec} seems to perform better than gap^{orth} as a proxy of inflationary pressure in the context of the four inflation upsurges, two episodes of deflation and the recent positive but low level of inflation.

The next criterion is based on correlations with annual CPI inflation (Table 3).

Correlations with the contemporaneous inflation rate and the one-year-ahead inflation rate are larger for gap^{elec} than for gap^{orth}.

Third, we estimate conventional Phillips curves by using both output gaps and examine their goodness of fit. A conventional Phillips curve is typically formulated as follows.

$$\pi_t = \theta_1 + \theta_2 \cdot \pi_{t-1} + \beta \cdot gap_t \qquad (10)$$

where π_t is annual CPI inflation. We use both contemporaneous and one-year lagged output gaps in the estimation. The sample period is from 1970 to 2004. Estimation is by Ordinary Least Squares (OLS).

Table 4 summarizes the results. The results based on the one-year lagged orthodox output gap are inferior to other results. This is because the estimated β is not significant. The other three results are similar to each other.

These results indicate that the electricity output gap, gap^{elec}, is a better proxy of inflationary pressure than is gap^{orth}. The intuition behind this result is that gap^{elec} is not affected by the measurement errors in real GDP and that gap^{elec} might effectively reflect the intensity of labor input. Therefore, we use gap^{elec} as our production function-based output-gap measure.

The fitted values from the Phillips curve estimated by using gap^{elec} match the actual fluctuations in the inflation rate closely (Chart 10). The estimated parameter for gap^{elec} is significantly positive, which implies that the output gap, in part, drives the fluctuations in the inflation rate. There are large fluctuations in the residual in Chart 10. In 1988 and from 1993 to 1994, there are large positive residuals from the Phillips curve. This suggests that not only has economic prosperity (a positive output gap) contributed to inflation upsurges but so have price adjustment and liberalization. By contrast, there are large negative residuals in 1990. This may indicate that, although the main reason for a sharp decline in the inflation rate was monetary tightening (the negative demand shock), the tentative postponement of price liberalization by the central government also contributed to reducing inflation (Oppers, 1997).

4-2. An Analysis of Recent Inflation Dynamics

Here, we use quarterly data to investigate the relationship between the inflation rate and the output gap, focusing on movements after the 1990s. For this purpose, we use not only the electricity output gap but also the output gap measured by using the time-series approach as a complementary method.

4-2-1. The Output Gap based on the Time-series Approach

We first estimate the output gap by using the time-series approach. In related literature on inflation in China, Gerlach and Peng (2004) estimate the output gap by using real annual GDP from 1982 to 2003. To do so, they use the Hodrick–Prescott (HP) filter, cubic polynomials, and the unobservable-components model. They conclude that the estimated output gaps are similar to each other and that their movements appear to be associated with fluctuations in inflation. They also point out that the basic Phillips curve does not fit the data well, which suggests that significant changes in economic structure affect inflation dynamics.

We use the logarithm of quarterly real GDP from 1987Q1 to 2004Q4 and estimate the potential output and output gap by using the HP filter and the band-pass filter. We set the smoothing parameter for the HP filter (λ) that governs business cycles *a priori*. If $\lambda = 0$, potential output is equal to actual output, but as $\lambda \to \infty$, potential output approaches a linear trend. Gerlach and Peng (2004) set $\lambda = 100$, which is the most frequently used value for annual data (and implies $\lambda = 1{,}600$ for quarterly data). Cooley and Prescott (1995) point out that using the HP filter with $\lambda = 100$ eliminates fluctuations at frequencies below 32 quarters, or eight years. Since we know of no widely accepted stylized facts on the periodicity of the business cycle in China, we use three values for λ: namely, 160, 1,600 and 16,000. For the band-pass filter, we choose the Christiano–Fitzgerald type (full-sample asymmetric) filter because it allows measurement of the end-of-sample gap.[22]

Chart 11 and Table 5 both compare four measures of the output gap based on the time-series approach, similarly to how we compare the output gaps based on the

[22] The parameters of the Christiano–Fitzgerald filter are used by EViews by default.

production function approach. The band-pass output gap performs better than the others on the criteria of coincidence and correlation with inflation and the estimated conventional Phillips curve. Hence, we choose the band-pass output gap to represent output gaps based on the time-series approach.

4-2-2. Characteristics of Recent Inflation Fluctuations

Next, we use quarterly data to estimate the electricity output gap by following the same procedure used on annual data. We first regress electricity consumption per unit of capital on two linear time trends. One trend increases by one each quarter from 1978Q1. The other is zero before 2002Q1 and increases by one each quarter thereafter. We treat the cyclical component of electricity consumption per unit of capital multiplied by the production elasticity of capital as the output gap. We estimate the conventional Phillips curve to check that the estimated coefficient of gap^{elec} is significantly positive (see Table 5).

Comparing the output gaps based on electricity data and the band-pass filter with annual CPI inflation reveals the following characteristics of recent inflation dynamics (see the middle panel of Chart 11).

(1) There are significant upswings in the output gap in the high-inflation periods, in which CPI inflation reached its peaks in 1988 and 1994. This suggests that China's economy overheated in these periods.

(2) The output gap was negative (suggesting recession) during the deflationary period of 1998-1999, while both output gaps were around zero in the deflationary period from the end of 2001 to the end of 2002. This implies that in the latter period, deflation was mainly due to factors other than recession, such as a decline in raw-material prices.

(3) The output gaps have remained close to zero since late 2002. That is, recent growth rates of demand and supply have been well balanced.

(4) A rise in the inflation rate from late 2003 does not suggest that China's economy is overheating, because it is due to a temporary shock.

The residuals from the estimated Phillips curve are serially correlated (see Table 5). These results suggest that relevant variables may have been omitted from the regression. In other words, factors other than the output gap probably influence inflation dynamics in China. We discuss such factors in the following two sections.

5. The Relationship between Input and Output Prices

An alternative basic analysis of inflation dynamics involves examining the impacts of input (or factor) price fluctuations on output prices.[23] Theoretically, it is consistent with profit maximization for a firm to set its output price equal to the nominal marginal cost of one additional unit of output multiplied by the mark-up. Due to the unique characteristics of China's economy, it is not appropriate to apply such a theoretical model directly to China. However, it is empirically appropriate to assume that fluctuations in factor prices are spread over output prices over time, because output prices are weighted averages of factor prices and the mark-up. Therefore, we investigate the influence of real wages and the prices of raw materials and intermediate goods on CPI inflation.

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[23] It is commonly applied in many countries to measure output gaps and to estimate conventional Phillips curves because of operational ease and goodness of fit to the data. This approach, however, has several drawbacks. For example, the conventional Phillips curve only represents an empirically observed relationship between the output gap and the inflation rate and has no microfoundations for explaining the behavior of economic agents. Thus, academics and economists of central banks have adopted the New Keynesian Phillips curve (NKPC), which is derived from the profit-maximizing behavior of firms, as the standard tool for inflation analysis (Ugai and Kamada, 2004; Kato and Kawamoto, 2005).

A standard NKPC is formulated as follows:

$$\pi_t = E_t \pi_{t+1} + \phi \cdot rmc$$

where rmc is real marginal cost (measured as the deviation from equilibrium). Real marginal cost is a combination of real factor prices (e.g., real wages or real prices of intermediate goods) of one additional unit of output. In the NKPC framework, rmc represents the gap between the actual and potential (equilibrium) economy.

Empirical studies of the NKPC have been conducted in various countries. For China, Ha et al. (2003) analyze inflation dynamics by using the NKPC. However, we refrain from estimating an NKPC in this paper and only investigate the relationship between factor prices and CPI inflation. This is for a number of reasons. (1) We are not sure that firms, especially SOEs, maximized profits before 1997. (2) It is difficult to obtain sufficient data for estimating the NKPC by using the Generalized Method of Moments (GMM).

5-1. Fluctuations in Real Wages

We first calculate unit labor cost (ULC) by dividing total personnel costs by real GDP. We then compare ULC to the annual CPI inflation. In Chart 12, the annual growth rate of ULC rose during the four inflation upsurges. This is consistent with the view that wage increases lead inflation. ULC growth differed in the two periods of deflation. ULC declined between 1997 and 1999, because of the reform of SOEs, while it increased in 2002. This suggests different causes of two deflation episodes.

Theoretically, given perfect flexibility of prices and nominal wages (W), there is full employment, and the real wage (W/P) matches the marginal productivity of labor. However, if nominal wages are sticky, real wages may differ from the marginal productivity of labor. Such a gap is known as the real wage gap. If real wages are lower than the marginal productivity of labor, the real wage gap is negative, and an increase in firms' profit puts downward pressure on inflation and upward pressure on wage growth.

To check this mechanism, we estimate the real wage gap in China. Following Kimura and Koga (2005), we treat the linear time trend for labor productivity (Y/L) as a proxy of the marginal productivity of labor.[24] Chart 13 shows the real wage gap estimated as the ratio of the real wage to the marginal productivity of labor. The real wage gap is positive from 1978 to 1996 and negative from 1997 to 2003. This implies that before the systematic reform of SOEs began in 1997, the real wage exceeded the marginal productivity of labor and led to higher inflation. By contrast, the real wage has been below the marginal productivity of labor since 1997. This means that wages have put downward pressure on inflation and upward pressure on wage growth.

According to Maruyama (2002) and Yueh (2004), wages in SOEs in the mid-1990s were controlled by two regulations. One specified that the growth rate of total wages must be lower than that of after-tax productivity. The other was that per capita wage growth must be lower than the growth rate of labor productivity. Given the move towards a market economy, the extent of wage control is unclear. Local authorities, however, still regulate the minimum wage and some benefits. While wage bonuses

[24] We assume two linear time trends: one increases by one annually from 1978 and the other is zero before 1997 and increase by one annually thereafter. The rationale for the second trend is that the earnest reform of SOEs possibly stimulated labor productivity growth.

appear to be based on the profit growth of firms, sections or individuals, authorities influence the fixed components of wages.[25] Moreover, although SOEs tend not to maximize profits, they seek to increase the average wages of their employees. Therefore, it is possible that real wages in China rise because of changes in wage policies but are not matched by increases in labor productivity.

5-2. Influences of Raw-Material and Intermediate-Good Prices

Three indices of raw-material and intermediate-goods prices that are related to output prices are widely analyzed. The first is the Raw Material Purchasing Price Index (RMPI), published by the National Bureau of Statistics. It is a weighted average of prices of raw materials and energy used in production. The second index is the Ex-Factory Price Index of Industrial Products (PPI), also published by the National Bureau of Statistics. This index is based on the prices of manufactured goods at the time of shipment. The third index is the Corporate Goods Price Index (CGPI), published by the People's Bank of China, and is based on aggregating transaction prices between firms. Chart 14 indicates the annual growth rates of these three indices. As Feyzioglu (2004) points out, the prices of raw materials and intermediate goods dropped significantly in both the deflationary periods. This is consistent with the view that declining input prices causes deflation. However, these three price indices rose substantially and remained high from 2003 to mid-2004.

Import prices also influence output prices if a country imports intermediate goods. Because official statistics on import and export prices are not available, we examine the movements in import and export prices estimated by Nakamura et al. (2005). They treat China's export prices as being equal to the prices of goods imported from China by Hong Kong. For China's import prices, they construct an import-weighted average of prices. They assume that import prices for raw materials equal the RMPI and that import prices of machines and other goods equal the corresponding prices of goods re-exported by Hong Kong to China. In Chart 15, the fluctuations in China's import price are similar to those of the three price indices examined above. Chart 16 shows the terms

[25] For example, a prevailing view is that authorities intervene in the wage determination process by monitoring. Another view is that the fixed components of private firms' wages are partially linked to public-sector wages.

of trade, i.e., the ratio of export prices to import prices. The terms of trade have deteriorated recently, which suggests that procurement costs through trade have risen.

Finally in this section, we measure the correlations between the growth rates of these four price indices and CPI inflation based on quarterly data. In Table 6, the growth rates of the three price indices excluding RMPI are positively correlated to that of the CPI. These results indicate that fluctuations in the prices of raw materials and intermediate goods are partially transmitted to the CPI.

6. Money, Output and Prices

In the previous two sections, we focused on the short-run impact of economic fluctuations on inflation and did not pay attention to the role of money. However, a conventional view is that monetary aggregates affect the economy because economic activities are settled through money, as the Policy Planning Office at the Bank of Japan (2003) points out. It is also generally accepted that inflation is a monetary phenomenon in the long run. Moreover, China's history includes several episodes of overheating and upsurges in inflation that are accompanied by sharp increases in monetary aggregates. Hence, we investigate empirically the relationship between money, output and prices.

6-1. Background Literature

We can consider monetary aggregates as practically useful indicators if they satisfy the following conditions. First, the relationship between monetary aggregates, output and prices is stable. Second, monetary aggregates contain unique information not conveyed by other economic statistics. For example, monetary aggregates are useful if monetary aggregates or liquidity levels statistically influence economic activities.

A large literature analyzes the relationship between monetary aggregates and economic activities in China. Hasan (1999) estimates an error correction model based on the equation of exchange and makes two findings. First, there is a long-run equilibrium relationship between the price level and money. Second, money largely affects prices. Chow and Shen (2004) estimate a VAR for prices, output and money. They find that

output is the first to react to monetary shocks but the response does not last and that prices respond more slowly but the response lasts longer. Zhong (1998) examines correlations and Granger causality between monetary aggregates, real industrial production and the RPI and finds evidence of one-way causality from money to real production and prices.

6-2. Long-run Equilibrium and the Vector Error Correction Model

We estimate a vector error correction model (VECM) that incorporates a long-run equilibrium relationship between the monetary aggregate (M2), real GDP and CPI by using quarterly data from 1987Q1 to 2004Q4.[26]

We first check whether the three variables follow stationary processes. We use the Augmented Dickey–Fuller (ADF) test, the Phillips–Perron (PP) test, the Elliot–Rothenberg-Stock's Dickey–Fuller test augmented by Generalized Least Squares (DF-GLS) and the Kwiatkowski–Perron–Schmidt-Shin test (KPSS).[27] In each test, we use an auxiliary equation that includes only a constant or one that includes a constant and a linear time trend.[28] All test results confirm that the three variables follow nonstationary processes (Table 7).[29, 30]

Next, we examine whether there is a long-run equilibrium relationship (i.e., cointegration) between these three variables by using the Johansen test. We find evidence of one long-run equilibrium relationship (Table 8).

We then estimate a VECM.[31] Table 9 summarizes the results. The estimated parameters for the long-run equilibrium relationship and the error correction terms are significant and signed as expected from economic theory. The results imply that the divergence of money from its equilibrium level precedes changes in output or prices.

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[26] All variables were seasonally adjusted by using the X-12-ARIMA method.
[27] We use both the DF-GLS test and KPSS test for two reasons. (1) In small samples, the DF-GLS outperforms the ADF and PP tests. (2) The KPSS test is superior to the ADF and PP tests because the KPSS test can detect stationarity for series that are close to being I(1).
[28] Lag selection was based on the general-to-specific approach (Ng and Perron, 1995) having set the maximum lag by following Schwert (1989).
[29] When there is a structural break in the constant term and/or a linear trend, it is more likely that stationarity is mistaken for nonstationarity. Hence, these results are interpreted with caution.
[30] Although we do not present these results because of limits on space, the first differences of these variables are stationary.
[31] The lag length of the VAR in the test equation is three.

Chart 17 compares the inflation rate, and the difference between actual M2 and its equilibrium level to output and prices, i.e., the money gap. The money gap clearly leads the inflation rate. The correlation coefficient is maximized (at 0.75) when the money gap leads the inflation rate by eight quarters. Granger causality tests confirm this one-way causality from the money gap to the inflation rate.

These results suggest that there is an alternative transmission mechanism from money to output and prices in addition to the standard mechanism operating through interest rates and the output gap (represented by the IS curve). In China, the transmission mechanism for monetary policy that operates though interest rates is underdeveloped. Hence, the main policy instruments are those used to directly control the quantity of money, such as window guidance from the People's Bank of China and administrative measures of the State Council. In addition, the banking system dominates China's financial markets: 80 percent of household financial assets are in the form of currency and deposits (in 2000 on a flow basis), and 70 percent of corporate finance comes from bank lending. Under such circumstances, the long-run equilibrium relationship between money and economic activity seems persuasive.

These arguments indicate that monetary aggregates (more precisely, the money gap for M2) is an important information variable for predicting economic activity, particularly inflation.

6-3. The Influence of the Transition to a Market Economy

The final issue addressed in this section is the influence of the transition to a market economy on the relationship between money, output and prices. For this purpose, we estimate the same VECM as in the previous section on the subsample period before 1996Q4. We identify one long-run equilibrium relationship between the variables, as before (Table 10).

In the results from the subsample, the estimated coefficients of the error correction terms for real GDP growth and CPI inflation are smaller in absolute value than those for money. In the context of the VECM, the larger the absolute value of the error correction parameter, the faster the convergence to the long-run equilibrium. This

implies that money dynamics were primarily responsible for adjustment to the long-run equilibrium before 1996. It is also implies that automatic economic stabilizers based on price adjustments had little effect because of price regulations. In the full-sample results, the estimated error correction parameters are generally larger than those from the subsample. This implies that the transition to a market economy may have improved the shock absorption mechanisms that are operated through price adjustment in China. Hence, it can be concluded that China's economy has become more stable. That is, China would experience smaller business-cycle fluctuations than before, because of improved market adjustment to shocks.

7. Concluding Remarks

This paper has undertaken a comprehensive empirical analysis of inflation dynamics and mechanisms in China. This section concludes by discussing important issues relating to inflation in China. (For an overview, see the abstract or the nontechnical summary.)

(The Current Situation Relating to Inflation in China)

The first issue is the current situation relating to inflation in China. The decomposition of CPI inflation by the SVAR revealed that the positive supply shock of 2000 had almost died out by the end of 2004. Both the electricity output gap and the band-pass output gap remain close to zero. Although the prices of raw materials and intermediate goods rose, the negative wage gap may have contributed to keeping the inflation rate low. Combining these observations, we can conclude that China's economy had no inflationary pressures at the end of 2004.

(Future Outlook for Inflation)

The second issue is the outlook for inflation. Based on the government's economic plan presented at the Third Session of the 10th National People's Congress (5-14 March), the target growth rate for real GDP is "around 8 percent." The output gap would be about zero throughout 2005 if this growth target were achieved. The money gap, which is a leading indicator of inflation, was small but negative at the end of 2004. The

target growth rate for M2 in 2005 is "below 15 percent" and seems consistent with projected economic growth. Therefore, it is reasonable to project that CPI inflation will stay low in the short run unless the economy faces unexpected and significant shocks.

In the medium and long run, however, there is a risk of an inflation upsurge. We list the following three risk factors.

The upward pressure on nominal wages is the first risk. As we indicated above, historically, significant wage inflation leads CPI inflation. In the labor market in China, there are signs of a significant mismatch between labor demand and supply. The effective vacancy ratio has increased slowly, although the unemployment rate remains high in urban areas (Table 11). Wage differentials have recently increased (Chart 18). Wage increases in coastal areas are common. These elements imply that a continued high rate of economic growth in China may lead to average nominal wage increases because of labor-market tightness in specific sectors or areas.

The second risk of higher inflation rate originates from high raw-material and intermediate-good prices, particularly energy prices.[32] The prices of energy sources and related products have been set below those in international markets by the authorities. However, it has been reported recently that the authorities plan to liberalize these prices to transfer fluctuations in energy costs to final-good prices. Therefore, the recent upward pressure on inflation observed in 'upper-stream' industries may influence the prices of 'lower-stream' products more than previously.

The last risk comes from expansionary fiscal policy. For example, local governments may expand their expenditures to support incomes in rural areas. Capital injections for state-owned banks may also increase fiscal expenditures.

(Implications Relevant to Monetary Policy)

The third issue discussed is the implication of this study for China's monetary

[32] The State Development Planning Commission released a letter on 5 April, which stated "If the CPI inflation rate exceeds 1 percent (month-on-month) or more than 4 percent (year-on-year) for three months, no price increase is admitted for the next three months". This letter asked local authorities to not only observe price movements, particularly those on food, chemical fertilizers, oil, coal, and steel materials, but also to observe the extent to which higher prices of producer goods affected the prices of lower stream products.

policy. The output and money gaps indicate that the Chinese authorities have recently controlled the economy well, given our focus on macroeconomic data.

In market-oriented economies, most central banks conduct monetary policy by guiding real interest rates with reference to 'a natural rate of interest'. It is reasonable to assume that the natural rate of interest is equal to potential growth. Then, one can measure the gap between the actual and natural rates of interest.[33] Chart 19 shows the real interest rate gap in China. There are two large negative gaps, in 1992–1996 and 2003–2004. This implies that the low real interest rate stimulated the economy during these periods. Thus, quantitative monetary control, through, e.g., administrative restrictions on bank lending, was required to prevent overheating. On the other hand, the relaxation (or removal) of upper limits on lending rates, which was introduced on 29 October 2004, is expected to reinforce the transmission mechanism for monetary policy that operates through interest rate adjustment.

(Directions for Future Research)

The last issue is the direction for future research. This paper has used official Chinese statistics. Thus, the accuracy of the analysis inevitably depends on the data used and their quality. In addition, the empirical studies presented are not based on the behavior of economic agents but on 'rules of thumb'. This means that the empirical results may change as individuals' expectations change. The progress made in the transition to a market economy may also have affected the estimated relationships. Hence, tasks for future research are to overcome these shortcomings and produce improved empirical analysis based on new data.

[33] We assume a potential growth of 8.5 percent because China's potential growth between 1995 and 2004 has been estimated at around 8.5 percent on the basis of the production function. The real interest rate is derived by subtracting the annual CPI inflation from the nominal base rate for lending.

Appendix: Sources and Definitions of Data

1. Real GDP

Source of Annual data: CEIC.

Quarterly GDP data from 1987Q1 to 1999Q3 are available from http://cources.nus.edu.sg/cource/ecstabey/tilak.html. Observations from 1999Q4 were calculated by multiplying by the annual growth rate of real GDP, released by the National Bureau of Statistics (NBS, source: CEIC). We obtained its seasonally adjusted logarithmic series by using the X-12-ARIMA method.

2. Consumer Price Index (CPI)

Source of Annual data: CEIC.

We obtained the monthly series for the CPI as follows. First, we constructed levels data from November 2002 to October 2003 by multiplying the levels data for November 2002 by the monthly growth rates of the CPI (not seasonally adjusted), which are available from China Monthly Economic Indicators (NBS). Then, we constructed a non-seasonally adjusted series for the CPI from January 1987 to December 2004 by linking data based on annual CPI inflation (source: Datastream). The seasonally adjusted series (in logarithms) was derived by using the X-12-ARIMA method.

The CPI excluding food, CPI^{exfood}, is calculated as follows.

$$CPI^{exfood} = (CPI \cdot 100 - CPI^{food} \cdot w^{food}) / (100 - w^{food})$$

where CPI^{food} is the price of food in the CPI and w^{food} is the weight on food.

We assumed that w^{food} is 44.0 percent before 2000 and 33.6 percent after 2001. The value of w^{food} is based on data released by the NBS on 15 June 2004 (only the Chinese version is available).

3. Retail Price Index (RPI)

Source of annual and monthly data: CEIC.

4. Labor Input

Annual data on labor inputs were obtained from the China Statistical Yearbook published by the NBS (Source: CEIC). We assumed that employment is equal to 'Total Employment' from 1970 to 1989 and is equal to the total 'Number of Employed Persons at the Year-end by Sector' from 1990 to 1997, following Young (2003). We linked the series from 1998 to 2004 with the previous series by using the annual 'Total Employment' rate (having assumed that the growth rate for 2004 was equal to the average

of the 1999–2004 growth rates).

5. Capital Stock

We extended the series for the capital stock from Chow (1993) by using the method of Chow and Li (2002). We assumed an initial capital stock at the end of 1952 of 2,213 (million yuan) and added 'Accumulation' from http://fbsstaff.cutyu.edu.hk/efkwli/ChinaData.html to the initial capital stock from 1953 to 1978. Although the data on 'Accumulation' are in current prices, we followed Chow (1993) and assumed no price change in capital goods during the period.

For observations from 1978 to 2003, we calculated the value of 'Real Net Fixed Investment' by subtracting real consumption and real net exports (derived by deflating nominal values by the RPI and the implicit GDP deflator, respectively) from real GDP. Then we added to this the depreciation-adjusted capital stock of the previous year to obtain the value of current capital stock. The depreciation rate was assumed to be 5 percent, which is the average depreciation rate for the period 1993–2003, calculated by using the procedure of Chow and Li (2002). The capital stock for 2004 was obtained by multiplying the value for 2003 by the average growth rate of the capital stock from 1999 to 2003.

Quarterly data were obtained by assuming equal quarterly increases in each year.

6. The Labor Share

The labor share is the ratio of 'Compensation of Employees' from the 'China Statistical Yearbook' to nominal GDP. The labor share data used in the production function approaches are averages for the period 1993–2003 (excluding the outlier observation for 1995).

7. Electricity Production

Source of the electricity data: CEIC.

We replaced missing data on electricity production from 1985 to 1995 by using the annual growth rate in electricity consumption and replaced missing data from 1970 to 1984 by using the annual growth rate of energy consumption. We also replaced the outlier observation for 1975 with the average value for the period 1974–1976.

Quarterly data from 1996Q1 are electricity production data, and data before 1995Q4 represent quarterly electricity consumption, obtained by dividing the annual data by four.

8. Real Wages

Source of nominal wage: CEIC.

Quarterly data series were obtained by assuming quarterly growth rates in each year as the same. We calculated real wages by dividing nominal wages by the CPI (and by the RPI before 1984).

9. Labor Productivity

Labor productivity is measured as the ratio of real GDP to labor input. For labor input, we used the number of employees, which was derived by dividing the 'Total Wage' by the 'Annual Average Per Capita Wage', rather than 'Total Employment'.

10. Price Indices of Raw Materials and Intermediate Goods

Source: CEIC.

Three indices were used: 'Purchasing Price Indices of Raw Materials, Fuel and Power' (from the NBS from January 1989); 'Ex-Factory Price Indices of Industrial Products by Sector' (from the NBS from January 1997); and 'Corporate Goods Price Indices' (from The People's Bank of China from January 1994).

11. Real Bank Lending Rate

Annual data series were obtained by subtracting annual CPI inflation from the 'Nominal Interest Rate on Loans of Financial Institutions (Term: 1 year)', from the China Statistical Yearbook.

Quarterly data were obtained by subtracting annual CPI inflation from the 'Nominal Interest Rate on Loans of Financial Institutions (Term: 1 year)', from the China Monetary Policy Report of The People's Bank of China.

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Chart 1 Real GDP Growth and Inflation

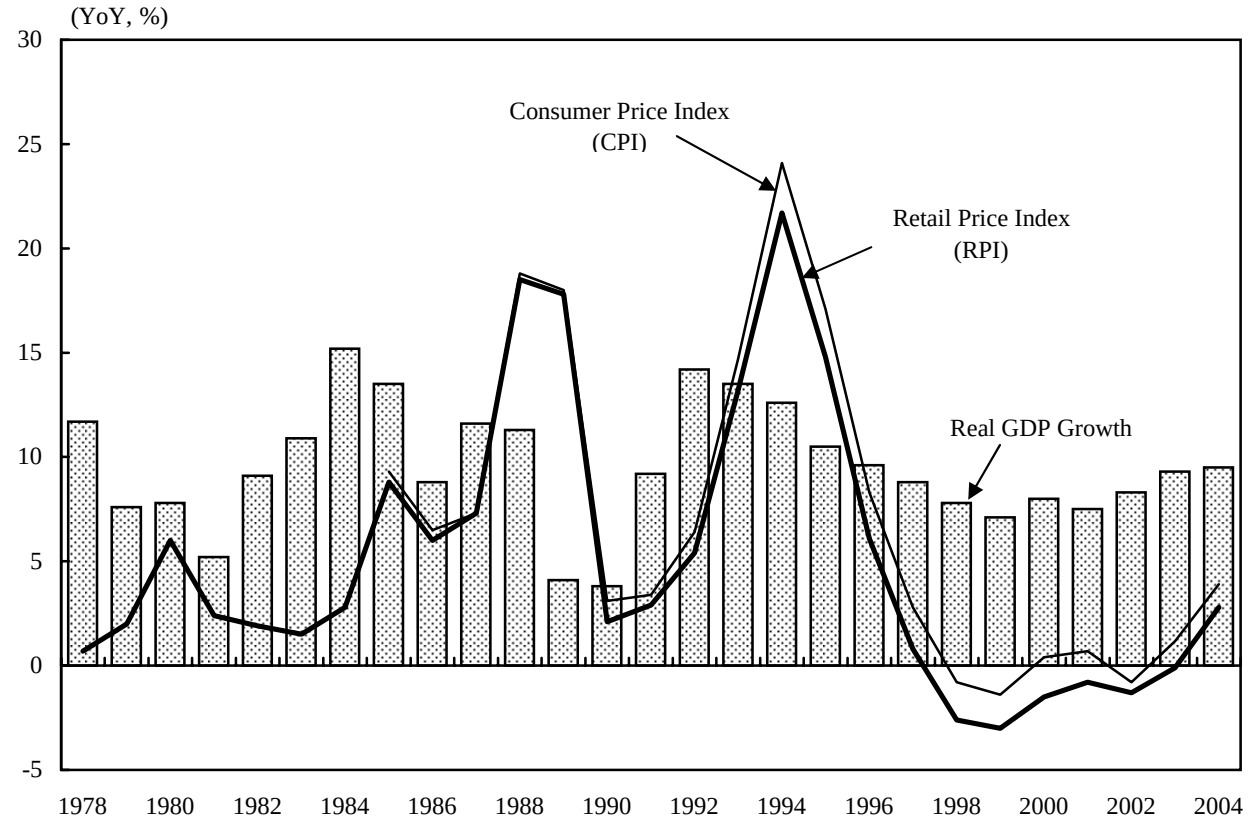


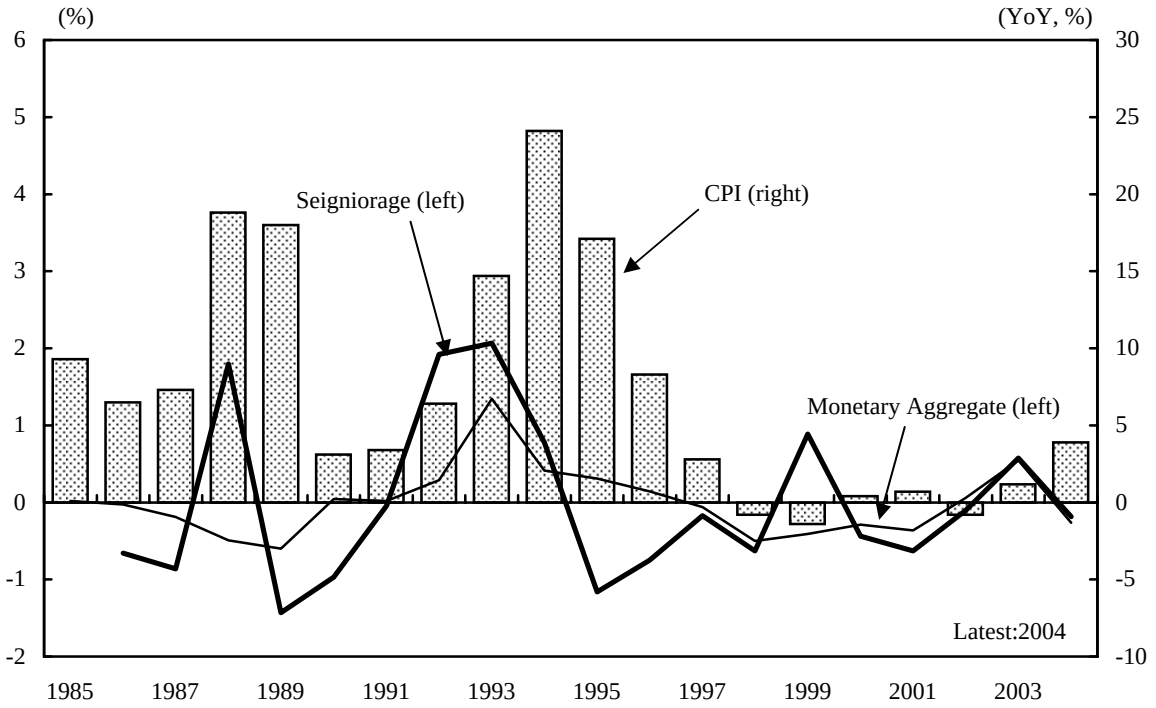
Table 1 Price Liberalization

(Share of Item, %)

	1978	1984	1985	1988	1990	1991	1992	1993	1994	1995	1996	1997
Retail Goods												
Administered +Guided price	97.5	84.0	63.0	55.0	47.0	31.2	7.0	6.2	9.6	11.2	7.5	6.8
Market price	2.5	16.0	34.0	45.0	53.0	68.8	93.0	93.8	90.4	88.8	92.5	93.2
Agricultural Products												
Administered +Guided price	94.4	81.9	60.0	48.0	48.4	42.2	18.2	12.5	20.7	21.4	21.0	19.5
Market price	5.6	18.1	40.0	52.0	51.6	57.8	81.8	87.5	79.3	78.6	79.0	80.5
Production Goods												
Administered +Guided price	100.0	-	-	-	63.6	54.3	26.2	18.9	20.0	22.1	18.9	18.4
Market price	-	-	-	-	36.4	45.7	73.8	81.1	80.0	77.9	81.1	81.6

(Source) Ohashi(2003)

Chart 2 Seigniorage, Monetary Aggregate and Inflation



(Note)Seigniorage is the ratio of the increase of M0 over the nominal GDP.
Monetary Aggregate is the ratio of the increase of M2 over the nominal GDP.
Both are detrended.

Chart 3 Amount of Bank Lending

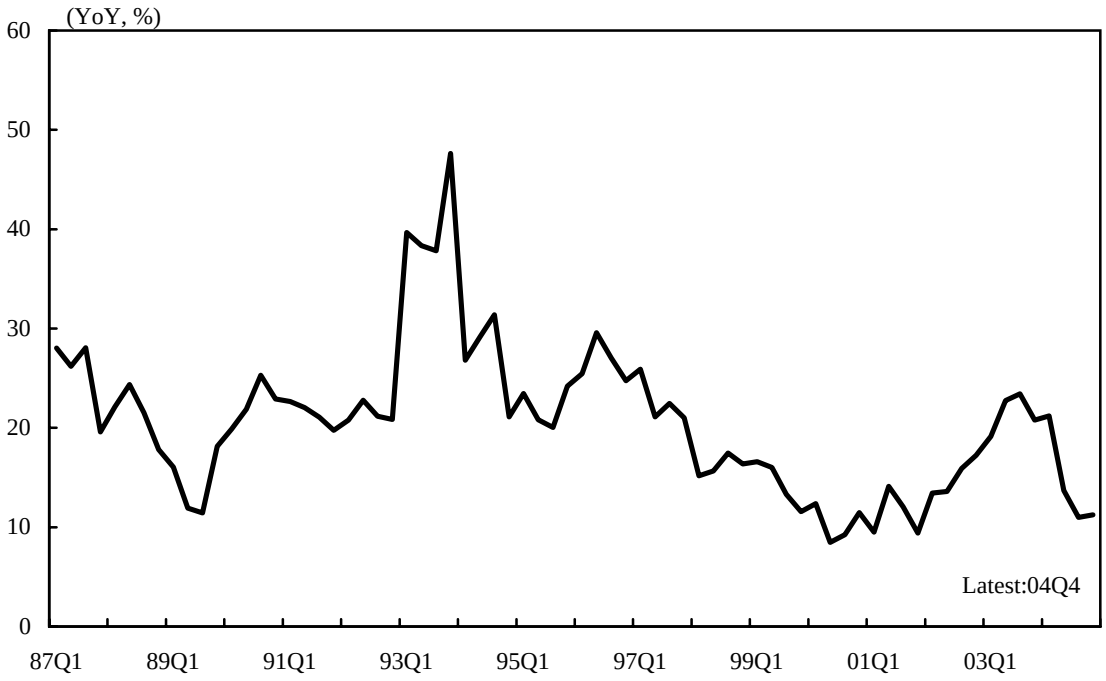
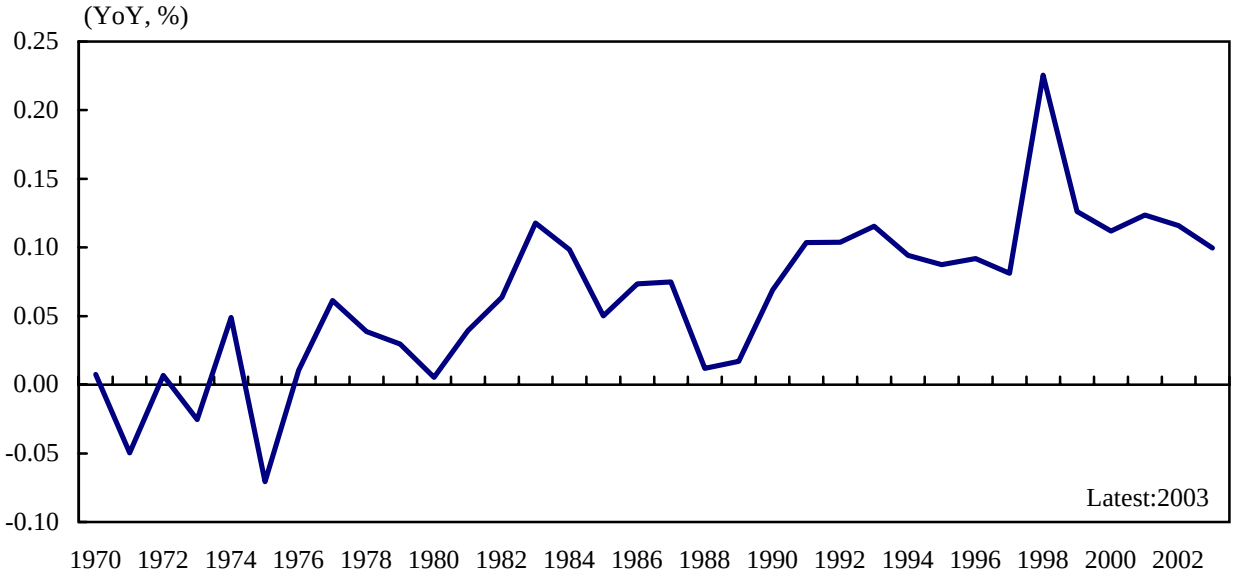
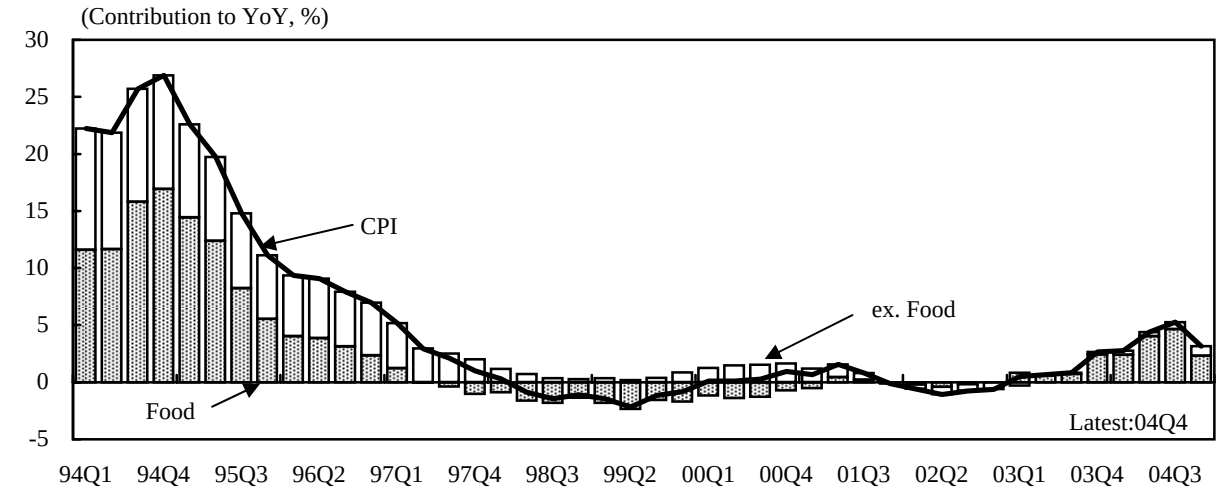


Chart 4 Labor Productivity



(Note)Labor Productivity: the real GDP over the number of employment.
Number of Employment: total wage payment over per capita wage.

Chart 5 Contribution Decomposition of the Year-on-Year Rate of CPI



<Closeup of ex. Food Contribution>

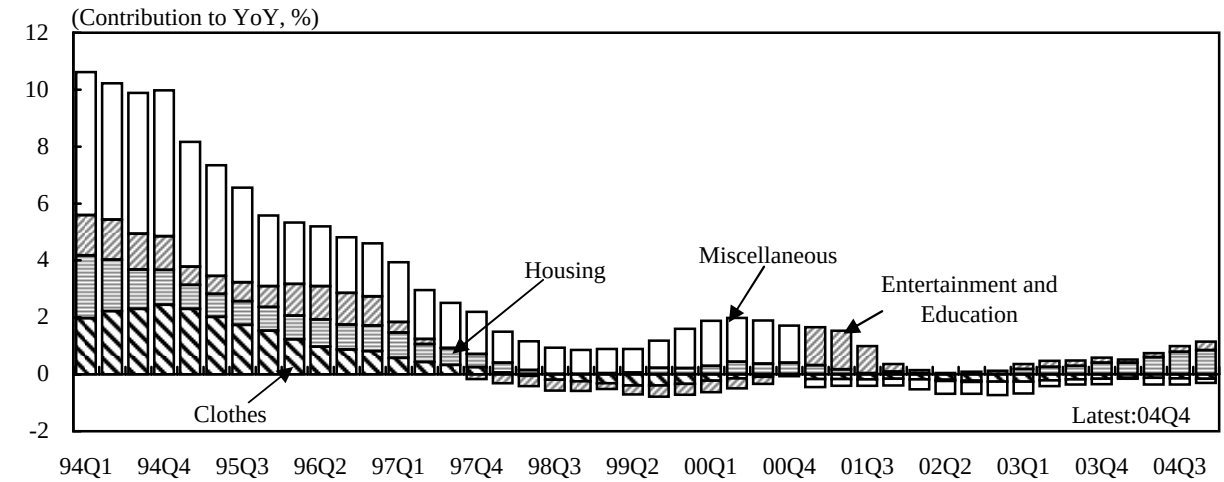
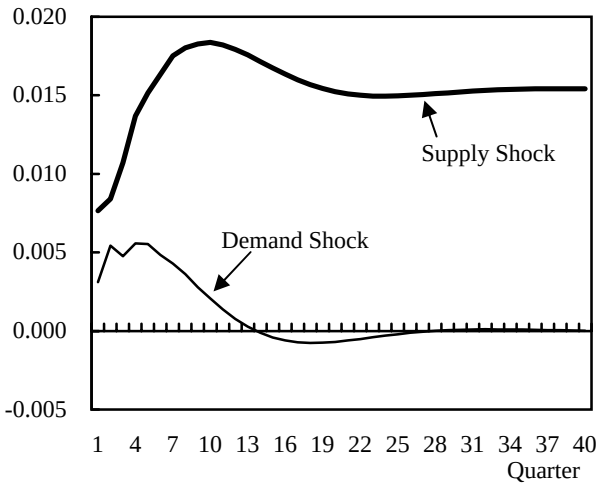


Chart 6 Accumulated Impulse Response of SVAR

(Sample Range:1987Q1-2004Q4)

Real GDP



CPI

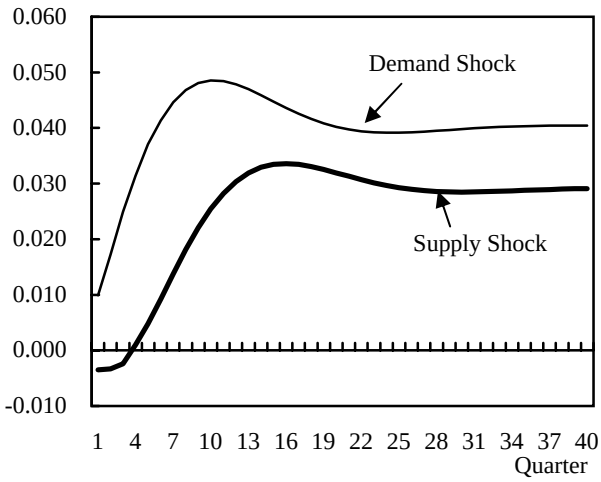


Table 2 Variance Decomposition

(Sample Range:1987Q1-2004Q4)

	Real GDP		CPI	
	Demand Shock	Supply Shock	Demand Shock	Supply Shock
1 quarters	14.2	85.8	88.9	11.1
4 quarters	18.1	81.9	91.1	8.9
8 quarters	18.2	81.8	76.4	23.6
12 quarters	19.9	80.1	70.0	30.0
24 quarters	20.1	79.9	69.6	30.4
36 quarters	20.2	79.8	69.6	30.4

Chart 7 Decomposition of the CPI Inflation

(Sample Range:1987Q1-2004Q4)

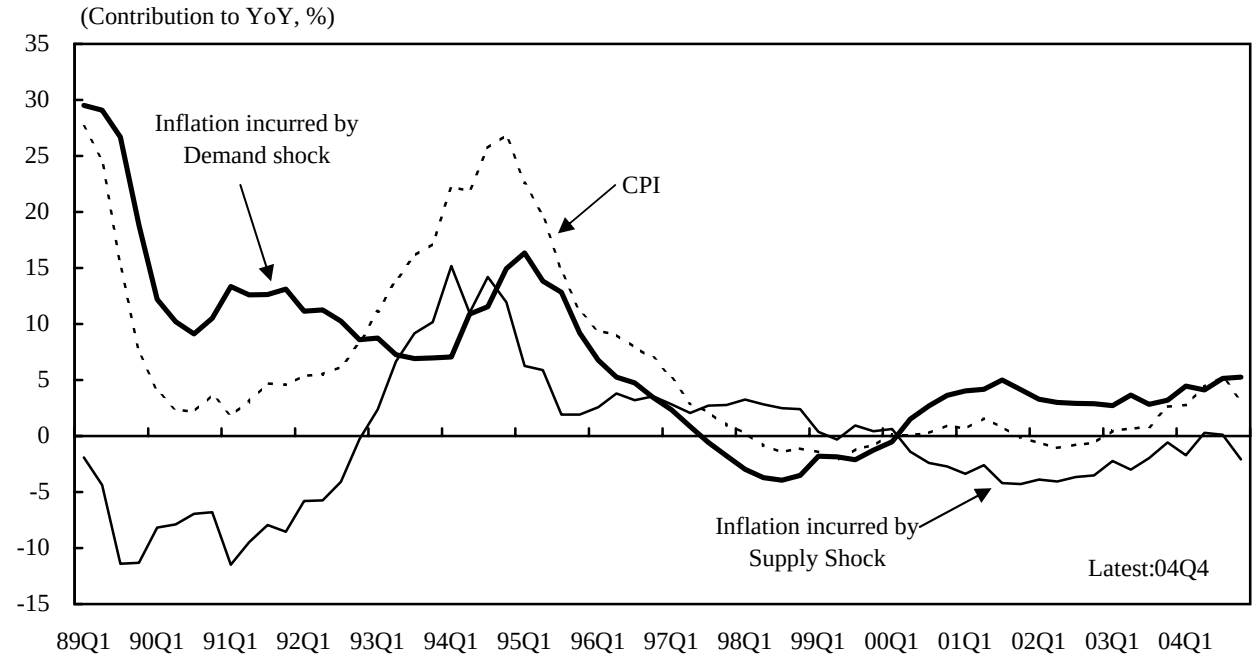
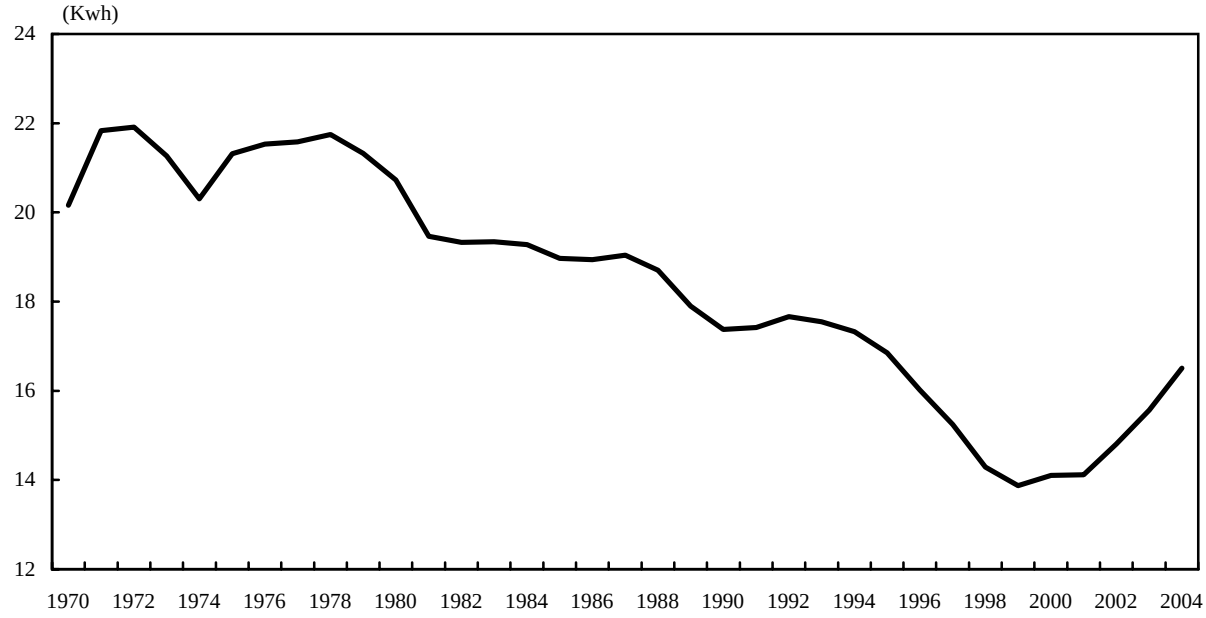


Chart 8 Electricity Consumption per Unit of Capital



(Note)Electricity Consumption per Unit of Capital=Electricity Production over Capital Stock.
Figure multiplied 100 is shown in the graph.

Chart 9 Two Output Gaps of Production Function Approarch

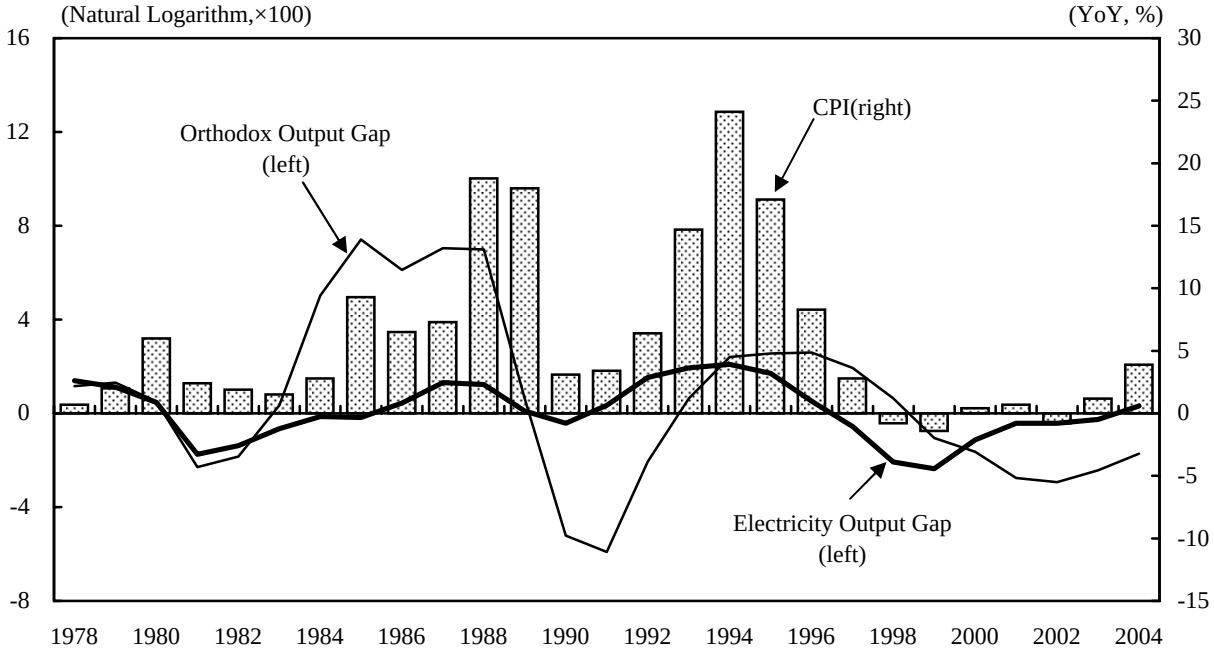


Table 3 Cross Correlation between Output Gap and Inflation (Annual Basis)

(Period:1970-2004)

Leads to the Inflation	-1	0	+1	+2	+3
Orthodox Output Gap	0.26	0.52	0.49	0.22	-0.01
Electricity Output Gap	0.30	0.57	0.64	0.45	0.08

(Note)-1 means GDP Gap lags behind the inflation.

Table 4 Estimation of the Conventional Phillips Curve (Annual Basis)

Output Gap	Orthodox		Electricity	
lags	0	+1	0	+1
θ1	0.02	0.02	0.02	0.02
	(2.18)	(1.82)	(2.40)	(2.49)
θ2	0.62	0.62	0.59	0.51
	(5.46)	(4.39)	(5.20)	(3.68)
β	0.61	0.31	1.83	1.75
	(2.89)	(1.19)	(3.19)	(2.51)
Adj.R^2	0.60	0.50	0.61	0.57
Breusch-Godfrey's LM test	6.45	7.00	7.65	5.79

(Note)Figures in the parentheses are t-statistics.

Chart 10 Actural CPI Inflation and Fitted Values of Conventional Phillips Curve

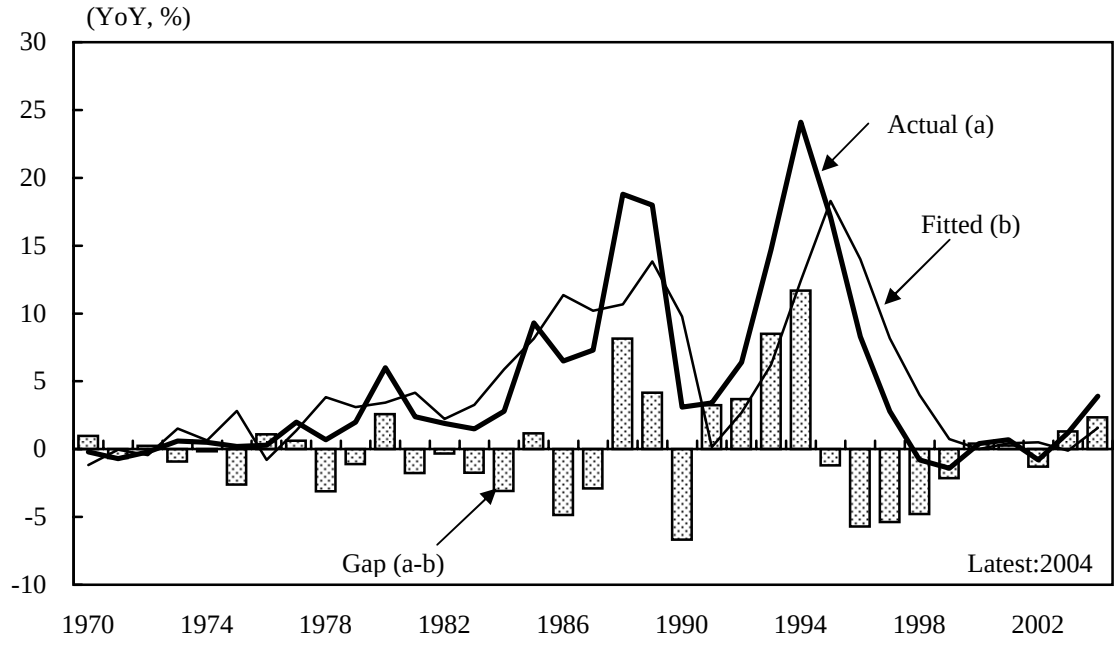
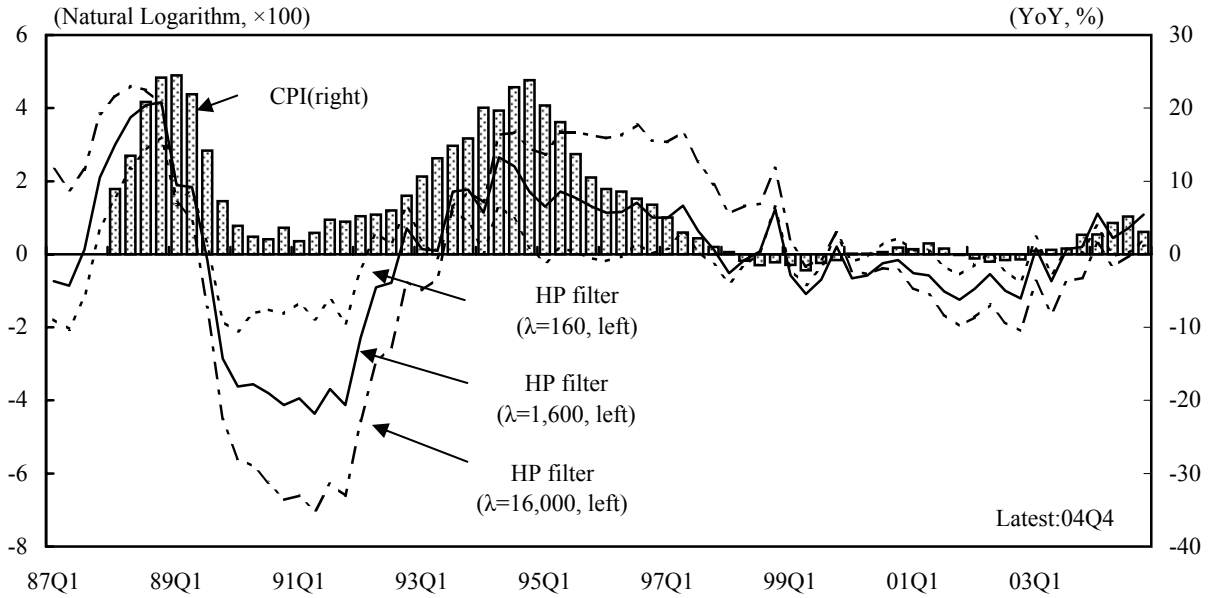
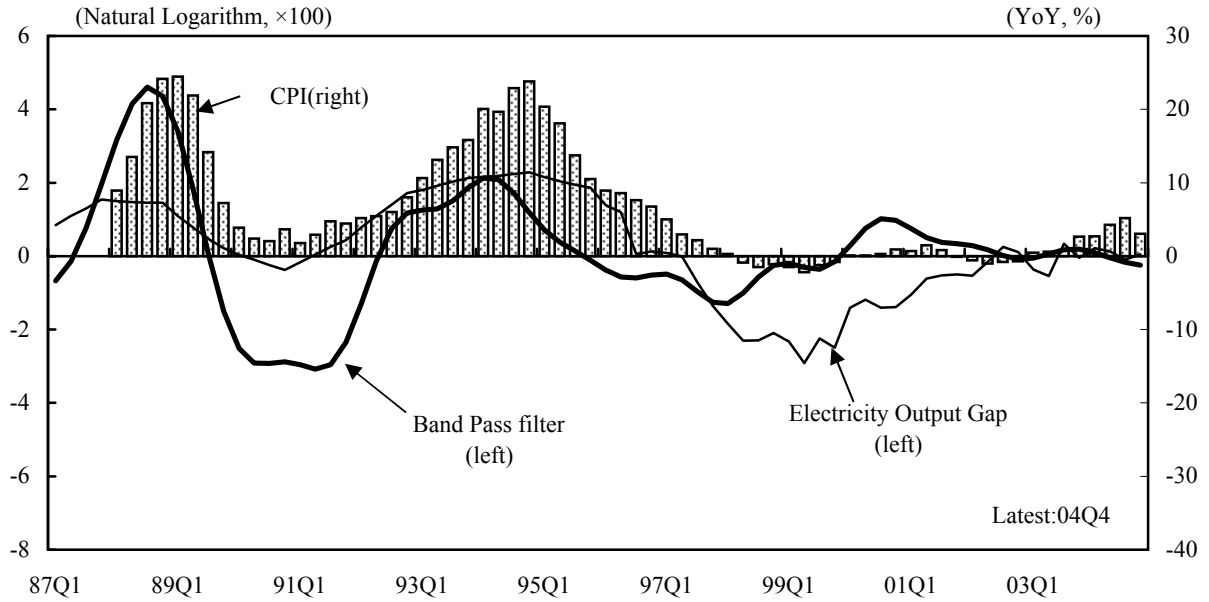


Chart 11 Output Gaps of Time Series Approarch and CPI Inflation





<Cross Correlation:Quarterly Basis>

(Period:1988Q1-2004Q4)

Leads to the Inflation	-1	0	+1	+2	+3	+4
Band pass filter	0.46	0.60	0.67	0.67	0.59	0.46
HP filter(λ=1,600)	0.40	0.43	0.46	0.49	0.53	0.57
HP filter(λ=160)	0.20	0.28	0.37	0.46	0.54	0.61
HP filter(λ=16,000)	0.62	0.63	0.62	0.61	0.60	0.58

Table 5 Estimation of the Conventional Phillips Curve(Quarterly Basis)

(Sample Period:1988Q2-2004Q4)

Output Gap	Band Pass		HP filter						Electricity	
			λ=1,600		λ=160		λ=16,000			
	OLS	AR(1)	OLS	AR(1)	OLS	AR(1)	OLS	AR(1)	OLS	AR(1)
θ_1	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.01
	(2.40)	(1.80)	(1.85)	(0.85)	(1.83)	(0.47)	(1.06)	(1.01)	(2.32)	(1.30)
θ_2	0.86	0.59	0.89	0.73	0.89	0.78	0.93	0.69	0.83	0.74
	(25.81)	(5.54)	(22.49)	(2.59)	(26.07)	(1.83)	(23.44)	(2.99)	(15.98)	(5.32)
β	0.96	1.62	0.54	0.43	1.30	0.40	0.16	0.34	1.05	1.11
	(6.00)	(3.59)	(3.43)	(1.67)	(5.04)	(1.20)	(1.64)	(1.46)	(3.37)	(2.50)
AR root		0.84		0.76		0.73		0.82		0.69
Adj.R^2	0.94	0.96	0.92	0.96	0.94	0.96	0.91	0.96	0.92	0.96
Breusch-Godfrey's LM test	23.74	1.41	28.26	1.81	18.56	2.48	30.73	1.40	31.18	0.47

(Note)Figures in the parentheses are t-statistics.

Chart 12 Unit Labor Cost and Inflation

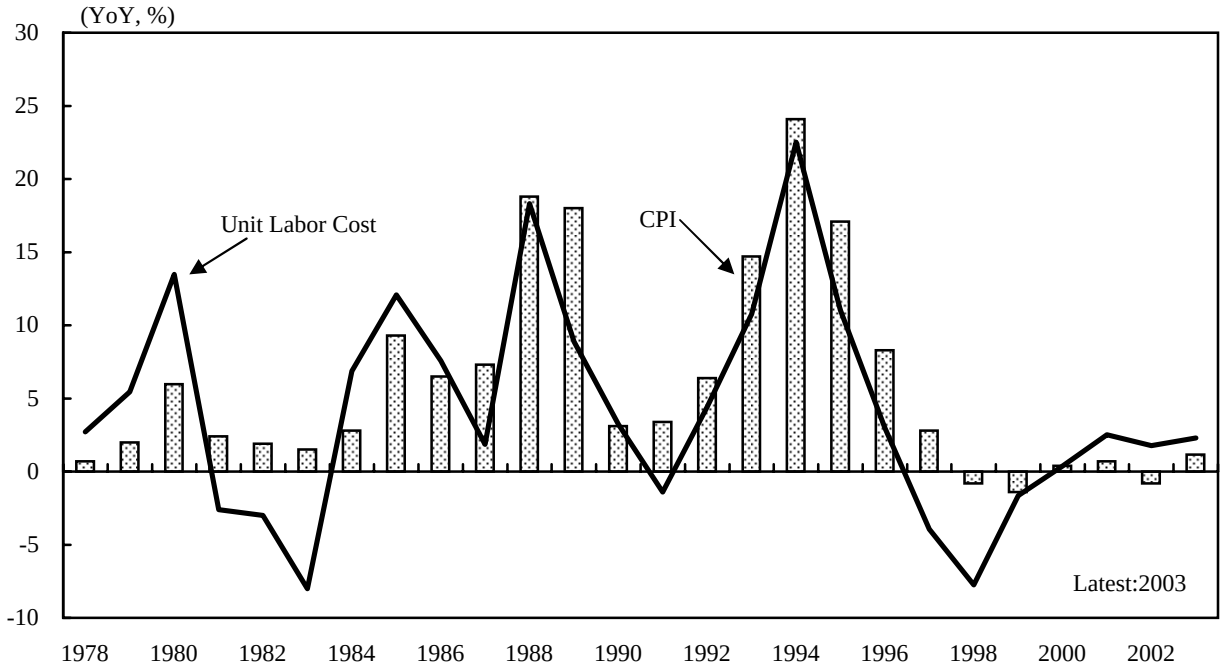


Chart 13 Real Wage Gap

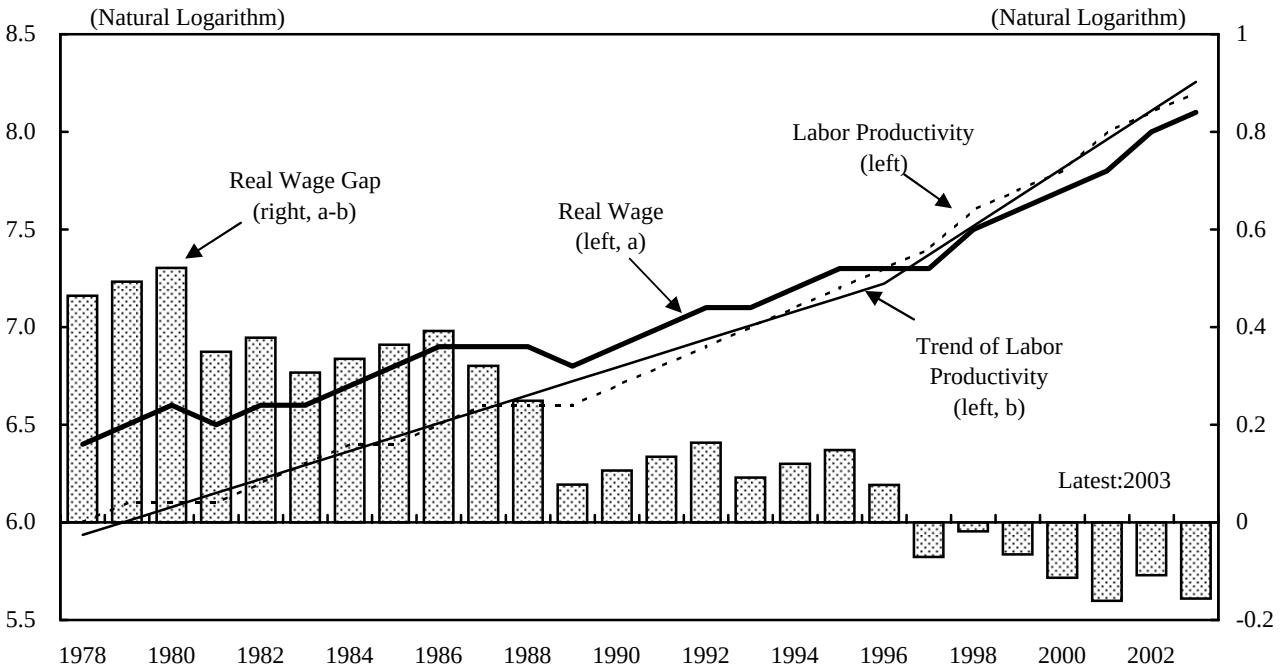


Chart 14 Prices of Raw Materials and Intermediate Goods

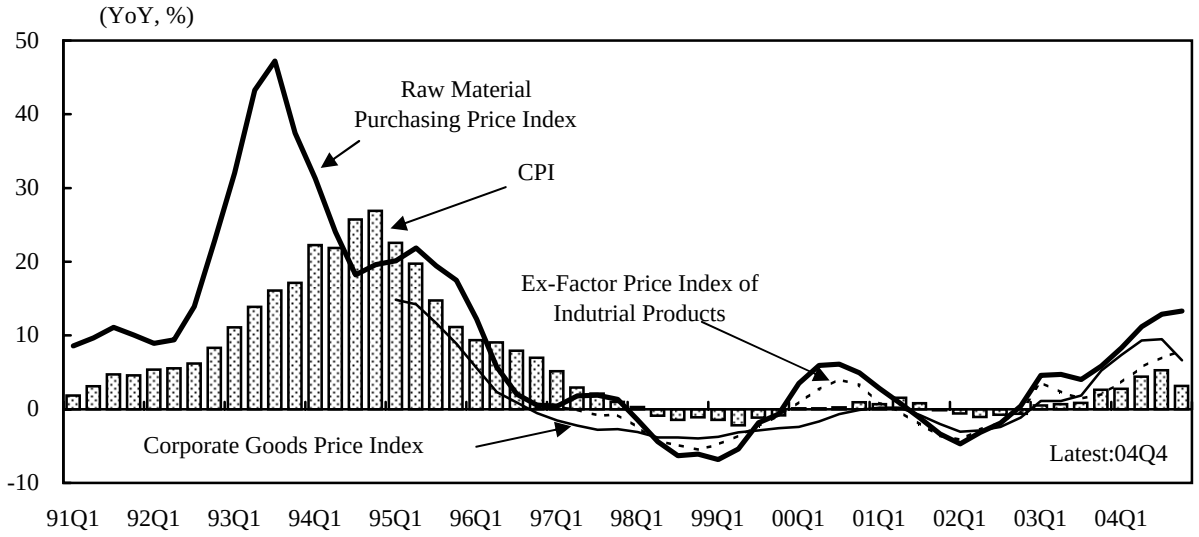
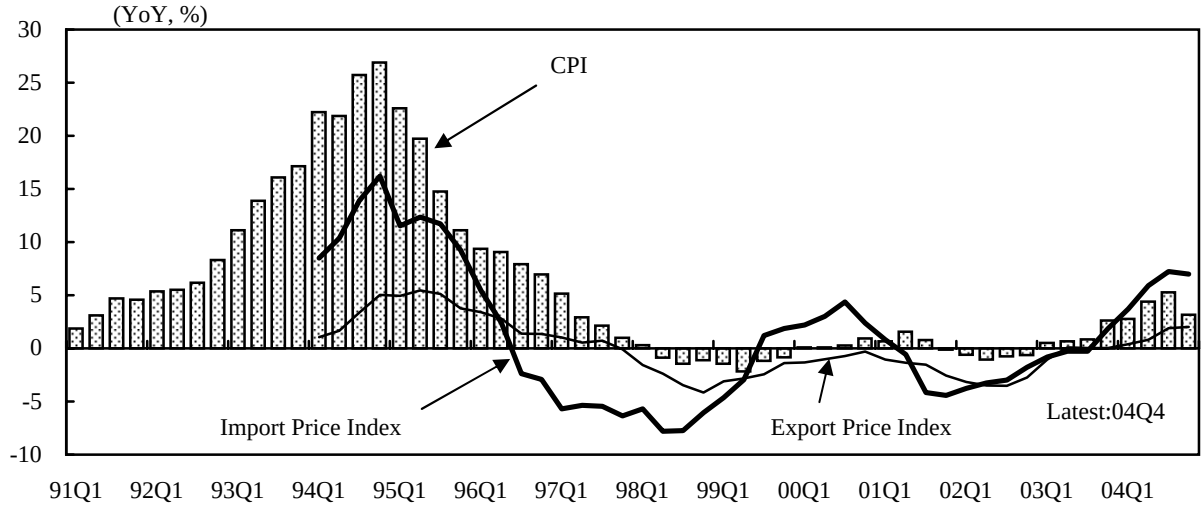


Chart 15 Export and Import Price Index



(Source)Nakamura, Kawana, and Oshima(2005)

Chart 16 Terms of Trade

Table 6 Cross Correlation among Several Price Indeices

(Period:1997Q1-2004Q4)

	Import Price	Raw Material Purchasing Price	Ex-Factory Price of IP	Corporate Goods Price	Consumer Price
Import Price	1.00	-0.46 (7)	0.61 (0)	0.66 (0)	0.53 (0)
Raw Material Purchasing Price		1.00	-0.36 (6)	-0.35 (1)	-0.33 (0)
Ex-Factory Price of IP			1.00	0.43 (0)	0.51 (3)
Corpotate Goods Price				1.00	0.77 (0)
Consumer Price					1.00

(Note)All series are seasonally adjusted by X-12-ARIMA. Cross Correlation is based on QoQ.
Figures in the parentheses are the number of leads of column variables to raw variables.

Table 7 Unit Root Tests

(Sample Period:1987Q1-2004Q4)

	Constant				Constant & Linear Trend			
	ADF	PP	DF-GLS	KPSS	ADF	PP	DF-GLS	KPSS
Real GDP	-0.354	-3.07	0.826	1.133***	-2.979	-1.568	-2.818	0.512**
	(0)		(4)		(4)		(4)	
CPI	-2.762*	-2.661*	-0.563	1.014***	-2.219	-0.905	-1.792	0.255***
	(2)		(2)		(2)		(2)	
M2	-3.039**	-2.318	0.222	1.122***	0.247	-0.186	-0.927	0.262***
	(0)		(3)		(0)		(3)	

(Note)*, **, *** mean the null hypothesis is rejected at the 10%, 5%, and 1% significant level, respectively. Figures in the parentheses are lag numbers.

Table 8 Cointegration Test

(Sample Period:1987Q1-2004Q4)

		Trace	Max Eigenvalue
Null Hypothesis	no cointegration	36.25	21.19
		(0.01)	(0.05)
	one cointegration	15.07	13.06
		(0.06)	(0.08)
	two cointegration	2.01	2.01
		(0.16)	(0.16)

(Note) Figures in the parentheses are p-value. Shadow areas show the null hypothesis cannot be rejected at the 5% significant level.

Table 9 Estimation of VECM

(Sample Period:1988Q4-2004Q4)

Long-run Equilibrium

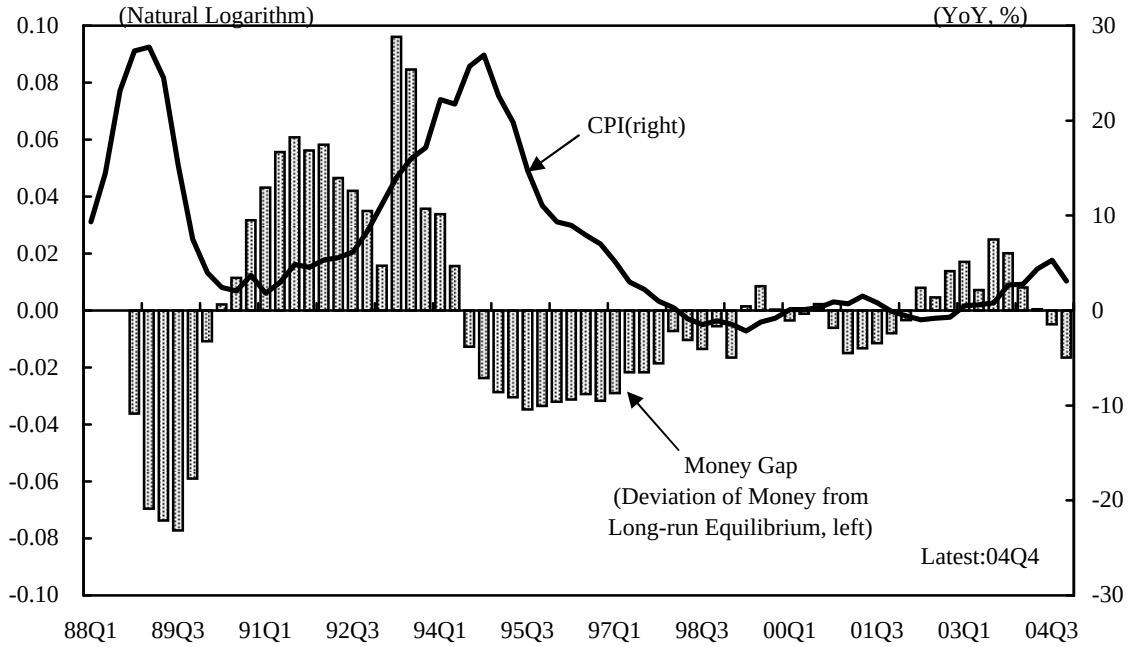
$$y + \underset{(0.036)}{0.435}*p - \underset{(0.012)}{0.544}*m - 4.589 = 0$$

VECM

Dependent Variable	Δy	Δp	Δm
EC	-0.216 ***	-0.153 ***	-0.454 ***

(Note) Figures in the parentheses are the standard errors. *, **, *** mean the null hypothesis is rejected at the 10%, 5%, and 1% significant level, respectively.

Chart 17 Money Gap and Inflation



(Note)Based on the estimation in Table 9.
Granger Causality test(Sample Period:1988Q3-2004Q4)shows one way causality:
Money Gap →YoY of CPI.

Table 10 Estimation of VECM(Sub-sample)

(Sample Period:1988Q4-1996Q4)

Long-run Equilibrium

$$y + \underset{(0.832)}{2.379}*p - \underset{(0.384)}{1.390}*m - 6.022 = 0$$

VECM

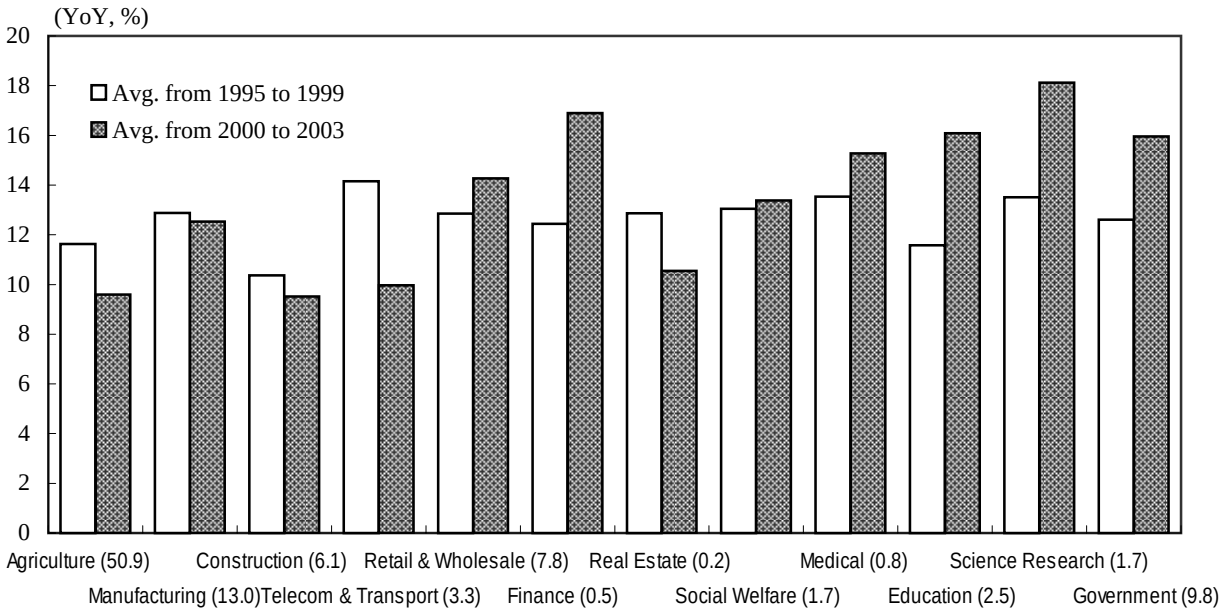
Dependent Variable	Δy	Δp	Δm
EC	-0.072 ***	-0.059 ***	-0.233 ***

(Note) Figures in the parentheses are p-value. *, **, *** mean the null hypothesis is rejected at the 10%, 5%, and 1% significant level, respectively.

Table 11 Unemployment Rate (UR) and Effective Vacancy Ratio

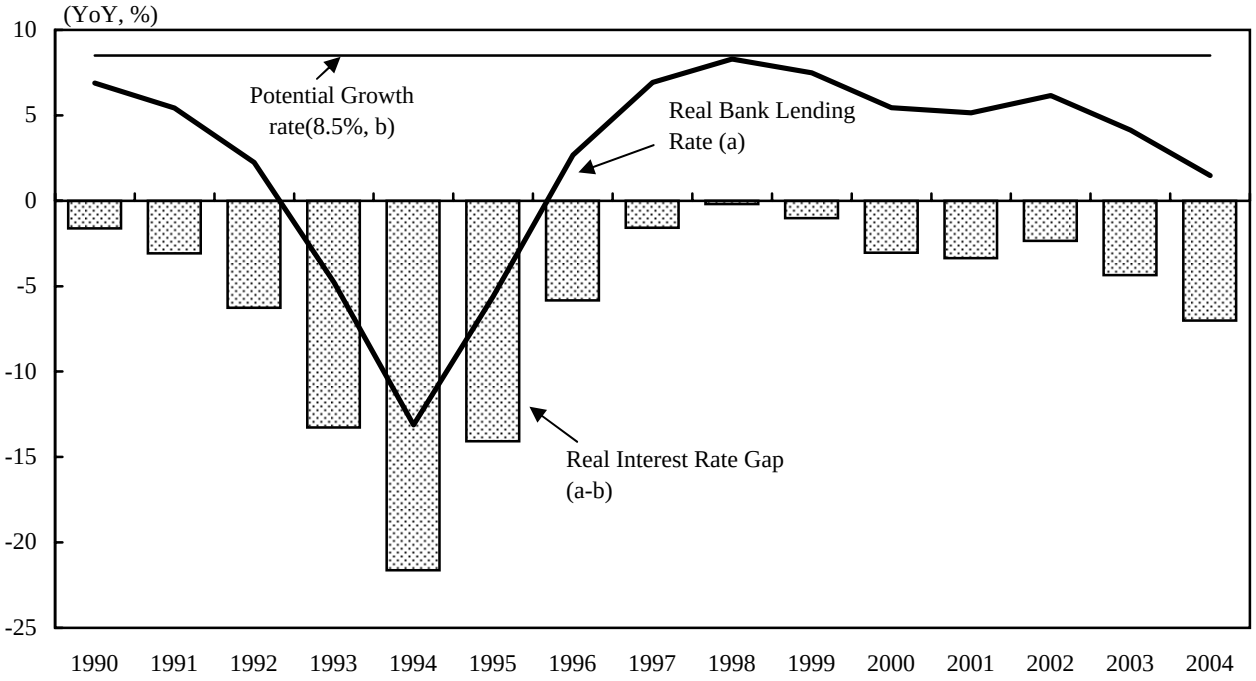
	2001				2002				2003				2004			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
UR (%)	3.6				4.0				4.1	4.1	4.2	4.3	4.3	4.3	4.2	4.2
Vacancy Ratio	0.65	0.69	0.75	0.75	0.73	0.74	0.78	0.89	0.86	0.89	0.90	0.88	0.89	0.93	0.94	0.94

Chart 18 Wage Increases by Sectors



(Note)Figures in the parentheses are shares of employee in each sector to the total employees in 2002.

Chart 19 Real Interest Rate Gap



(Note)The real interest rate for bank lending is defined as annual average of nominal interest rate for bank lending minus CPI inflation (YoY). The potential growth rate is assumed to be 8.5%.