GROWTH-INFLATION TRADEOFF IN CHINA

by

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Faculty of Social Sciences
Lingnan College
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Abstract

The high growth and wide fluctuations of fixed investment are the main driving forces of the rate of inflation in China in the reform period. Investment expansion generates strong demand pressures in the consumption goods market. Its inflationary impact is magnified further as it brings about higher wage costs during a boom. An implied short-run tradeoff is derived from dynamic simulation of a small macroeconomic model. In a given year, each additional percentage point of economic growth or investment growth leads to, respectively, a 2.7 or a 0.9 percent increase in the rate of inflation that year.

Journal of Economic Literature Classification Numbers: E31, P22.
1. INTRODUCTION

The Chinese economy has been growing at a remarkably high rate since the beginning of economic reforms in 1979. The mean growth rate of real net material product (NMP) in the 1979-1993 period jumped to 9.3 percent, 3.6 percent higher than in the preceding 24 years. Rapid output expansion, however, has been accompanied by an upsurge of inflation. During the 15-plus years under reform, the mean annual growth rate of the consumption goods price index (CGPI-based rate of inflation) climbed to 7.4 percent from a very low level (1.0 percent) in the pre-reform period. The rate of inflation also has considerable short-term variability. Following economic booms, double-digit inflation has been registered in four recent years (1988-1989 and 1993-1994). Is there a systematic relationship between inflation and high growth in the short-run Chinese economy? The objective of this paper is to investigate how the growth-inflation tradeoff arises and what are the numerical relationships behind it in China’s reform period.

According to one standard explanation for the tradeoff, rapid output growth led by strong aggregate demand during a boom generates inflation, because output is already near its capacity. As output is pushed above its potential, prices move upward along the aggregate supply curve. Because the economy’s potential growth rate is determined fully by supply-side conditions, such as the trend growth rates of productivity and factor inputs, output growth for an extended period at higher than the potential rate would bring about increases in the rate of inflation.

Another common explanation is the accelerationist hypothesis (Friedman, 1968, pp. 8-11). The potential rate in this hypothesis represents the highest growth rate achievable while maintaining a stable rate of inflation; above (below) this, the rate of inflation accelerates (decelerates). Accordingly, the tradeoff is not with the
rate of inflation but with its acceleration. At the potential growth rate, the labor market is in equilibrium, leaving the rate of unemployment at the NAIRU (nonaccelerating inflation rate of unemployment). Incremental demand for labor to achieve high output growth would, therefore, push the rate of unemployment below the NAIRU and set off a wage-price spiral through the expectations-augmented Phillips curve.⁴

The Chinese economy in the reform period has seen a series of strong economic booms, interrupted occasionally by sharp but relatively short downturns. The demand-side factors contributing to inflation, repeatedly acknowledged officially, are expansion of fixed investment, increases in household incomes, and fast growth of money supply (Tian, 1986; Liu, 1988; and Li, 1994)⁵. Because these variables generally move with output, one may expect some growth-inflation tradeoff. Nevertheless, China in the reform period has structural and institutional characteristics dissimilar to those upon which the standard explanations are based. Among these are the large size of the agricultural sector, whose output has high variability; the presence of a labor surplus; underdeveloped labor markets; and the government’s direct and indirect management of wages. These characteristics appear to modify the nature of the tradeoff, mostly from the supply and cost sides.

The basic idea of this paper is that the growth-inflation tradeoff arises from inflationary pressures originating in the expansion of fixed investment. The three demand-side factors act together, and the mode of China’s wage determination reinforces the inflationary process. I construct a macroeconomic model based on the features of the Chinese economy, estimate structural equations, and perform dynamic simulation of the model, to derive numerically the underlying tradeoff. This research relies on annual data. I review the macroeconomic data of the post-1979 period and discuss the structural
and institutional characteristics associated with the tradeoff in Sections 2 and 3. A macroeconomic model, estimated structural equations, and simulation results are presented in Sections 4 and 5. Main findings are summarized in the last section.

2. CHINA'S INFLATION: A REVIEW

Table 1 tabulates the annual growth rates of some macroeconomic variables associated with inflation in the reform period. The geometric-mean growth rates and standard deviations for the 1979-1992 period are listed at the bottom. (Those values may be cited in this section without specifying the period.) The Chinese economy achieved GDP growth of higher than five percent in all but three years--1981 and 1989-1990, which can be regarded as two periods of recession--since economic reforms began in 1979. There have been two long booms, one from 1982 to 1988 and the current boom since 1991. The rate of inflation, based on the consumption goods price index, began to rise and then stayed high during the second half of the boom in the 1980s, marking an upward shift in the mid-1980s. Two inflationary spells (1988-1989 and 1993 to the present) appeared and the rate of inflation has exhibited conspicuous cyclical patterns since the shift.

Among the series listed, variability is by far the highest in fixed investment. The standard deviations of the growth rates of total (1982-1994) and state (1979-1992) fixed investment are, respectively, 11.7 and 13.4 percent. Also notable is their rapid growth particularly since the beginning of the boom in 1982. State fixed investment expanded by 9.8 percent in the 1979-1992 period, and total fixed investment by 14.7 percent in the 1982-1994 period. These growth rates are higher than that of GDP (9.0 percent). State fixed investment, most of which is the capital formation of state enterprises, makes up about two-thirds of total fixed investment, and total investment's share of
## TABLE 1

### MACROECONOMIC DATA

<table>
<thead>
<tr>
<th>Year</th>
<th>Real GDP</th>
<th>CGPI</th>
<th>Agricultural output</th>
<th>Total</th>
<th>State</th>
<th>Total Consumption /GDP</th>
<th>Nominal Productivity</th>
<th>Labor Wage Productivity</th>
<th>Growth rate, %</th>
<th>Share, %</th>
<th>Growth rate, %</th>
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<tr>
<td>1979</td>
<td>7.6</td>
<td>2.1</td>
<td>6.1</td>
<td>-</td>
<td>2.9</td>
<td>-</td>
<td>8.1</td>
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<td>1980</td>
<td>7.8</td>
<td>7.0</td>
<td>-1.5</td>
<td>-</td>
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<td>-</td>
<td>10.8</td>
<td>20.8</td>
<td>4.4</td>
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<td>1981</td>
<td>4.5</td>
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<td>7.0</td>
<td>-</td>
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<td>20.1</td>
<td>8.3</td>
<td>6.8</td>
<td>1.2</td>
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<tr>
<td>1982</td>
<td>8.3</td>
<td>2.0</td>
<td>11.5</td>
<td>26.2</td>
<td>24.8</td>
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<td>6.7</td>
<td>5.0</td>
<td>4.5</td>
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<td>1.2</td>
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<td>12.9</td>
<td>23.2</td>
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<td>12.5</td>
<td>20.6</td>
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<td>1985</td>
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<td>1.8</td>
<td>30.3</td>
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<td>29.8</td>
<td>14.8</td>
<td>23.3</td>
<td>9.1</td>
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<td>3.3</td>
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<td>4.7</td>
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<td>7.4</td>
<td>15.4</td>
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<td>7.3</td>
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<td>4.6</td>
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<td>2.4</td>
<td>16.7</td>
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<td>27.3</td>
<td>9.7</td>
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<td>1992</td>
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<td>4.7</td>
<td>23.7</td>
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<td>13.0</td>
<td>21.6</td>
<td>11.5</td>
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<tr>
<td>1993</td>
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<td>13.0</td>
<td>4.0</td>
<td>25.3</td>
<td>14.7</td>
<td>39.7</td>
<td>10.5</td>
<td>-</td>
<td>11.9</td>
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<tr>
<td>1994</td>
<td>11.8</td>
<td>21.7</td>
<td>3.5</td>
<td>15.8</td>
<td>10.3</td>
<td>38.8</td>
<td>-</td>
<td>-</td>
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**1979-1992, %**

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<th>Mean</th>
<th>9.0</th>
<th>6.0</th>
<th>5.2</th>
<th>14.7*</th>
<th>9.8</th>
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<th>8.4</th>
<th>14.5</th>
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<tr>
<td>SD</td>
<td>3.4</td>
<td>5.7</td>
<td>3.9</td>
<td>11.7*</td>
<td>13.4</td>
<td>-</td>
<td>3.7</td>
<td>6.9</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Note. CGPI is the consumption goods price index. Mean is the geometric-mean growth rate. SD is the standard deviation of the growth rate. * 1982-1994 period. Agricultural output is the output of the primary sector in GDP in constant prices. Total fixed investment/GDP is based on the nominal series.

Personal consumption in constant prices is from the NMP accounts.

Source. See Appendix for Real GDP (under Y), CGPI (P), total fixed investment (x), state fixed investment (x), nominal wage (W), labor productivity (V). Agricultural output, personal consumption, and nominal GDP are from Zhongguo tongji nianjian 1993, pp. 31 and 46, and 1994 ed., pp. 32 and 41, and the State Statistical Bureau’s Communique, 1995, p. I.
GDP has been increasing, reflecting its high growth rate. The share was around 30 percent in a typical year until recently. In contrast with fixed investment, personal consumption, the largest demand component of GDP, has a relatively low growth rate (8.4 percent) and variability (standard deviation of the growth rate, 3.7 percent). Fixed investment can therefore be regarded as the main driving force of China's economic growth and cycles during the reform period; and because of this role, it should have had a strong bearing on the rate of inflation.

Although the steady increase of employment and the fast rise of wages (nominal wage in Table 1 is earned cash income per worker) enabled households to expand spending, personal consumption appears to have been constrained by the productive capacity of the consumption goods and services sectors throughout the reform period. The slow growth of agricultural output kept demand pressures in the consumption goods market high, because spending on food still makes up about a half of household cash expenditures in recent years. 'Under this condition, the government has adopted a policy of decontrolling food prices and scaling down rationing at a cautious pace.'

The extent to which agricultural output affects personal consumption by restricting market supply can be assessed roughly with the correlation of the two variables. Although the correlation coefficient of the growth rates of personal consumption and agricultural output in the same year is almost zero (1979-1992, -0.065), that of the current year's personal consumption and the previous year's agricultural output is sizable (1980-1992, 0.482), presumably on account of the timing of harvests. Harvest fluctuations often stem from random variations in climatic conditions, and such disturbances in supply conditions are transmitted to personal consumption and consumption goods prices accordingly. The tight and varying supply leaves the consumption goods market susceptible to demand pressures when household incomes grow abruptly.
Table 1 also indicates that the nominal wage grew annually by 14.5 percent and that the variability of the growth rate has been high (standard deviation, 6.9 percent). The growth rate of the nominal wage was more than twice as fast as that of labor productivity (real GDP per worker, annual growth rate, 6.0 percent), indicating clearly that wage increases resulted in significant rises in production costs. Needless to say, fast growth of nominal wages leads to higher demand for consumption goods. The presence of a labor surplus does not seem to have restrained the speed of wage increases. Despite the difference in growth rates, nominal wages and labor productivity appear to have moved along with GDP. It is reasonable to consider that the procyclical movement of labor productivity affected wage levels rather than the other way around. This brief review suggests that the behavior of prices during the reform period was subject to three elements: strong aggregate demand led by fixed investment, tight supply conditions in the consumption goods market, and the growth of wage costs. In the next section, I will investigate the first and third elements further and draw some conclusions about the nature of the growth-inflation tradeoff in China's reform period.

3. EXPLANATORY FRAMEWORK OF THE TRADEOFF

The Demand Side

Among the three demand-side causes of inflationary spells commonly cited (the growth of fixed investment, household incomes, and money supply), a significant part of the growth of household incomes originates from wage increases. If we set aside this source of inflationary pressures (to be discussed fully later), the three demand-side causes are largely related to each other, and for this reason can be analyzed together.

Under China's current partially-reformed economic system, fixed
investment moves more autonomously than household incomes and money supply, and it can sway the level of household incomes. Rapid expansion of fixed investment in the reform period can be thought of as one of the consequences of the gradualist reform policy applied to the state sector, in which investment decision-making has been decentralized without imposing strict financial accountability on enterprises. State enterprises bear little risk when embarking on investment projects, because the probability of being forced into bankruptcy as a result of poor investment decisions is very low. Expanded enterprises’ autonomy in investment activity under economic reforms therefore led to strong growth of fixed investment. As investment growth necessitates higher labor input in the investment sector of the economy, it leads to greater total wage bills through increased employment. Given the gestation period of investment projects and the tight supply conditions of agricultural products, the immediate effect of investment expansion on the consumption goods market would be the rise of demand pressures. As fixed investment grows rapidly along the cyclical path, pressures on the consumption goods market appear in the form of high and varying rates of inflation. This establishes a growth-inflation tradeoff for economic growth driven by fixed investment.

The growth of the money supply also follows investment in this process, because the state banking system, lacking managerial independence, finances fixed investment passively with loans. In his comments on monetary policy in China, Perkins (1993, pp. 135-137 and 1994, pp. 41-43) points out that the causation governing money supply in China works in reverse from what is expected in a market economy. Easy money policy brings about high investment in a market economy. In China, however, after years of reforms in banking and state enterprises, "the direction of causation still started with enterprise investment demand, and the banking system basically accommodated this demand (1993, p. 137)." Under these circumstances, the growth of fixed
investment, household incomes, and money supply move together, as observed during past inflationary spells.

**Wage Costs**

As the growth of fixed investment accelerated during the reform period, a series of policies in the field of labor compensation adopted since 1977 appear to have provided reinforcement mechanisms for demand inflation. Central among the policies was the wage reform in state enterprises implemented in two stages from 1977. The wage reform contributed greatly to the fast growth of cash income per worker in the reform period through raising the labor compensation of state-sector workers. In the first stage of the wage reform (1977-1984), the government restored piece rates and bonus payments, which were suspended during the Cultural Revolution (1966-1976), and implemented several rounds of promotions and upward adjustments of wage scales. Furthermore, state enterprises that fulfilled plan targets were allowed to establish reserves (Enterprise Reserve Funds) from profits applied to bonus payments, workers' welfare expenditures, and fixed investment in 1979. From 1983, the Substitution of Tax for Profits Program was introduced to replace the enterprise reserve fund system. Under this program, enterprises could keep after-tax profits, half of which could be applied to bonuses and workers' welfare spending. In the second stage of the reform (1984-1986), state enterprises adopted a wage system that linked the total wage bill, bonuses, and benefits to indexes of performances, such as increases in labor productivity, remitted profits and taxes, and retained earnings. The ceilings on bonuses were phased out and a bonus tax with a graduated rate structure was introduced.

These new measures under the wage reform provided state enterprises with greater discretion in determining labor compensation and allowed these enterprises to expand wage and bonus payments rapidly.
through the reform period. As mandatory wage plans and uniform wage scales were replaced by a complex set of indirect regulations, enterprise managers have, on the one hand, found much room to negotiate with upper authorities for favorable treatment or to circumvent regulations. On the other hand, greater managerial power granted to managers by the supervisory authorities exposed them to expectations and pressures from workers. The new regulatory environment has unwittingly strengthened the power of workers relative to that of the state in setting labor compensation.

Kornai and Walder consider the new power relations and nominal wage drift as inevitable consequences of the reformed socialist system. While the wage reform relaxed centralized control, "wage discipline imposed by private ownership, market competition, and unemployment" (Kornai, 1992, p. 533) is slow to emerge in the economy. Also enterprises are still able to find "cover for losses from any increase in wage costs" (ibid, p.532) by the state (soft budget constraint). Because the hiring and dismissal of workers is still subject to various formal and informal restrictions, cooperation by workers on payrolls is indispensable for enterprise managers to organize production smoothly. This leaves managers more dependent on workers than in the pre-reform period, and consequently there appears "a tacit alliance... between managers and workers, both of whom have an interest in retaining the highest amount of incentive funds while distributing it relatively equally." (Walder, 1987, p. 22) In such an environment, managers are held responsible for increasing employees' incomes and benefits. (Walder, 1989, p. 244).

Is the growth of nominal wage per worker in Table 1 consistent with the wage trend in state enterprises? Woo and his associates (1994, p. 433) report the findings from their survey of 300 large and medium-sized state industrial enterprises. Total labor compensation increased from 31.8 percent of value added in 1984 to 48.8 percent in 1988. The
share of taxes and remitted profits declined from 31.5 percent to 13.7 percent in the same period as a consequence. A study by Li and his associates (1993, p.64) indicates a similar rise in a broad category. The labor share of GNP based on their reconstructed factor-cost data grew from 43.2 percent in 1978 to 55.3 percent in 1990. This appears to indicate that the beneficiary of the dramatic distributional change in favor of labor during the reform period went beyond state-sector workers to workers in non-state enterprises and the agricultural work force.

The wage reform in the state sector has been part of a comprehensive policy on labor compensation. The wage conventions in the collective enterprises therefore followed the changes in the state sector. Policies directed toward incomes of the non-agricultural work force also has some links to those toward the agricultural one, because the government acts to keep the urban-rural income gaps from widening. Besides decollectivizing agriculture in the early 1980s, the government implemented several rounds of hikes in purchasing prices of agricultural products to augment the incomes of peasants. Consequently, an intended modest realignment of the wage system and distributional policies in the early years of the reform period appears to have triggered continued strong drives for high incomes from a wide spectrum of the work force. The growth of wages in the reform period, in addition to raising the labor share of output, continually generated inflationary pressures by pushing production costs upward.

As mentioned in the preceding section, the growth rate of the nominal wage per worker not only stayed high but also fluctuated widely, following the procyclical movement of the growth rate of labor productivity. The parallel movement of the two variables appears to reflect the wage-setting convention in the state sector. Total wage bills, bonuses, and benefits in state enterprises are linked with some performance criteria, one of which is the increase in labor
productivity in the reform period. Note that other performance criteria commonly used, such as increases in remitted profits and taxes and retained earnings, tend to move procyclically along with labor productivity. Therefore whichever criterion is adopted, the new mode of wage determination generally leads to the parallel movement of nominal wages and labor productivity. The source of the procyclical movement of labor productivity appears to be the presence of surplus workers in state enterprises. To maintain high employment in urban areas, the government until recently encouraged enterprises to increase their work force over time. Surplus labor kept on payrolls allows the industrial sector as a whole to expand output with a less than proportional increase in workers.

The Wage Function

To assess the underlying numerical relationships in China's wage setting during the reform period, I have estimated the wage function in four different specifications reported in Table 2. The data used for the wage function are from Table 1. When the current-year rate of inflation is included as an independent variable (I, III, and IV), the wage function and the price equation are estimated together by three-stage least squares (3SLS). In this case, the two equations are thought of as a block in a (block-recursive) macroeconomic model. The macroeconomic model to be introduced later includes one of the equation sets estimated here. The price equation in the macroeconomic model will be represented by the household consumption goods demand function. The dependent variable of the wage function is the growth rate of the nominal wage. Explanatory variables are the rate of inflation, based on the consumption goods price index (P) in the current and/or past years, and the growth rate of labor productivity (V) in the current year.

The coefficients of the rate of inflation in the previous two
### TABLE 2

**WAGE FUNCTION**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variable: Growth rate of nominal wage, %</th>
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<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Period: 1981-1992</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td>Estimation method</td>
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<td>$P_t$'s growth, %</td>
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<td></td>
<td>(4.052)</td>
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<td>$P_{t-2}$'s growth, %</td>
<td>-</td>
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<td></td>
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<tr>
<td>$V_t$'s growth, %</td>
<td>1.663**</td>
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<td>(11.554)</td>
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<td>$R^2$</td>
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<td>D.W.</td>
<td>2.421</td>
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</table>

*Note. The numbers in the parentheses are t statistics. * and ** indicate statistically significant at the 10% and 1% levels. a, adjusted $R^2$. 

12
years ($P_{t-1}$ and $P_{t-2}$) are not significant at the 10 percent level whether the current year’s rate of inflation is excluded (II) or included (III and IV). The signs of coefficients vary depending on specifications. If one assumes adaptive expectations, the expectations-augmented wage function should contain lagged rates of inflation as explanatory variables. The low levels of significance reported appears to suggest that expected inflation does not systematically affect nominal wages in the reform period. The Chinese economy lacks well-functioning labor markets, it has a sizable labor surplus (within and outside of the state sector), and labor compensation in the non-agricultural sector reflects the interplay of complex bargaining relations and government regulations. We may conclude that any of these characteristics keeps expected inflation from affecting wages in a predictable manner.

The coefficients of the current year rate of inflation (I, 0.527) are positive and significant at the one and 10 percent levels respectively, when past years’ rates of inflation are excluded (I) and the previous year’s rate of inflation is included (III). The coefficient becomes statistically insignificant in (IV), but the coefficients of the past two years’ rates of inflation included are also insignificant in this specification. The coefficients of labor productivity are positive and highly significant statistically in all four equations. The positive relationships of nominal wages with the current-year rate of inflation and the labor productivity growth rate confirmed were anticipated, because labor compensation for state-sector workers includes partial compensation for the rise in the cost of living and, as mentioned above, it is linked with some performance criteria such as the increase in labor productivity. It can be inferred that the government’s intention has been to keep the growth of nominal wages within close range of that of labor productivity. The estimated substantially-higher-than-unity coefficients of labor productivity growth rate seem to attest the strong bargaining position.
of workers in the new institutional environment.  

The positive coefficients of the current-year rate of inflation found imply the presence of a reinforcing mechanism through wage determination. Starting from a stable wage level, any new inflationary pressures set off an upward adjustment of the wage level. Also, the larger-than-unity coefficients of the growth rate of labor productivity imply the other reinforcing mechanism. When output fluctuates by demand shocks, the subsequent procyclical fluctuation of labor productivity turns into an even wider movement of nominal wages, amplifying the initial impact on prices from demand shocks.

**Short-run Inflation Dynamics**

Combining the demand-side factors and the mode of wage determination, China's short-run inflation dynamics during the reform period has been propelled mainly by the growth and fluctuation of fixed investment. Investment expansion generates new employment and brings about increases in aggregate output. Labor productivity rises as surplus labor within enterprises is used effectively. Such productivity gains and the cost-of-living adjustment bring about sizable wage hikes through the prevailing mode of wage determination in China. Household money incomes grow thanks to the rise in both wages and employment. In the face of slow supply increase, particularly in agricultural products, augmented household incomes exert demand pressures in the consumption goods market. Prices rise as a result of these pressures, allowing some producers to meet increased wage bills. While the rise of fixed investment serves as a demand shock that raises output, its initial impact on prices is amplified as the shock triggers cost increases through wage hikes. A growth-inflation tradeoff emerges as this process repeats.
4. MACROECONOMIC MODEL

I have constructed a calendar-year-based macroeconomic model incorporating the above features, which can be solved recursively. This model has two sectors--households and the business sector, the latter being either directly-owned or controlled by the government--and considers the markets for two goods (consumption and investment goods), an asset (money), and labor. The business sector operates two industries, which produce consumption and investment goods, and the state banking system. A sizable underemployed work force is assumed in the economy.

Notation

Numerical subscripts with minus signs are used to indicate past years (hence \(-1\) denotes the previous year). \(\Delta\) denotes the first difference. Endogenous variables are represented by capitals; exogenous variables are denoted by either lower case or Greek letters.

*Endogenous variables.*

\(G\) Nominal household incomes (expenditures of the business sector); annual aggregate.

\(K\) Capital stock in the consumption-goods industry in 1978 prices; value at year-end.

\(M\) Nominal money supply held by households; outstanding balance at year-end.

\(P\) Price of consumption goods (base year = 1978, 1978 level = 1).

\(Q\) Output of consumption goods (also the demand for consumption goods) in 1978 prices; annual aggregate.

\(V\) Labor productivity (average product of worker, annual) in 1978 prices.

\(W\) Nominal annual wage rate.

\(Y\) Gross material product (GMP) in 1978 prices.
Exogenous Variables.

$\gamma$ Interest rate on money held by households.

$x$ Gross fixed investment (output of investment goods industry, annual aggregate) in 1978 prices.

$\alpha$ Random supply shocks (mean = 1).

$\gamma$ Allocation ratio of new capital to the consumption goods industry.

$\xi$ Rate of depreciation.

Coefficients.

$\beta$ Reciprocal of the capital-output ratio in the consumption goods industry.

$\delta_i$ Distributed lags describing the pattern in which current and past years’ investment fully contributes to the expansion of capital stock.

The Model

\[ \Delta K = \gamma \sum_{i=0}^{j} \delta_{-i} x_{-i} - \zeta K_{-1}, \]

(1)

$K, x, \gamma > 0 \quad 0 < \delta_{-i} < 1 \quad \sum_{i=0}^{j} \delta_{-i} = 1 \quad 0 < \zeta < 1,$

\[ Q = \alpha \beta K, \]

(2)

\[ \bar{\alpha} = 1 \quad \alpha, \beta > 0, \]
\[
\left[ \frac{V}{V_{-1}} - 1 \right] = \theta_1 + \left[ \frac{Q_{-1}}{Y_{-1}} \right] (\alpha - 1) + \theta_2 \left[ \frac{x_{-1}}{Y_{-1}} \right] \left( \frac{x}{x_{-1}} - 1 \right),
\]
(3)

\[\theta_1, \theta_2 > 0,\]

\[G = \frac{\alpha \beta K + x}{V} + r_{-1} M_{-1},\]
(4)

\[W, r, M > 0\]

\[
\left[ \frac{W}{W_{-1}} - 1 \right] = \lambda_1 \left[ \frac{P}{P_{-1}} - 1 \right] + \lambda_2 \left[ \frac{V}{V_{-1}} - 1 \right],
\]
(5)

\[P, \lambda_1, \lambda_2 > 0,\]

\[\Delta Q = \mu \Delta \left[ \frac{G}{P} \right],\]
(6)

\[\mu > 0,\]

\[M = f(G, P, r, \ldots ),\]
(7)

\[G = PQ + \Delta M,\]
(8)

\[Y = Q + x.\]
(9)
Equation (1) describes the delay in transforming current and past investment into new capacity in the consumption goods industry. Equation (2) indicates that consumption goods output is subject to random supply shocks and is constrained by capital stock. Random shocks here are thought of as harvest fluctuations stemming from the variation of climatic conditions. The consumption and investment goods industries use Leontief technology. The investment goods industry, unlike the consumption goods industry, has slack capacity, and therefore its output is not constrained by capital stock. Equation (3) indicates that the growth rate of labor productivity depends on the trend growth ($\theta_1$) and the weighted sum of the random supply shock in the consumption goods industry (second term) and the output growth rate in the investment goods industry (third term). The investment goods industry hoards labor, and therefore labor productivity in this industry moves procyclically to its output. The expenditures of the business sector consist of wage payment (first term) and interest paid by the state banking system on money held by households (second term) in (4). The bracket in the first term represents the number of workers employed. The business sector, guided by government planners, sets the rate of increase in the annual wage in accordance with the growth rates of the consumption goods price (rate of inflation) and labor productivity (5).

Equation (6) is the household consumption goods demand function. This is a modified version of Hall's (1978, pp. 974-976) consumption function formulated by Campbell and Mankiw (1989).\footnote{14} Note that this function determines the price of consumption goods in the model (see footnote 15 for the order of iteration of the model). Equations (5) and (6) (together with equation 4) form a block in the macroeconomic model mentioned above and are identical to the equations estimated in Table 2-I.

Equation (7) is the household money demand function in a general form. Equation (8) is the budget constraint of households. Equation (9)
defines gross material product, GMP. Because output in this model excludes most services but includes the depreciation of capital stock, this term is used. Omitting Equation (7), eight endogenous variables are determined by this block-recursive model.\textsuperscript{15}

\textit{Estimation of Structural Equations}

There are five equations with unknown coefficients (1-3 and 5-6) in the eight-equation system. In the absence of capital stock data, however, the first two equations cannot be estimated. The remaining three equations are estimated with the data for the post-1979 period. The sources of the data are listed in the Appendix. Assuming that the second term is absorbed by the error term, Equation (3) is estimated by OLS:

\[
\left[ \frac{V}{V_{-1}} - 1 \right] = 0.0404 + 0.792 \left[ \frac{X_{-1}}{Y_{-1}} \right] \left[ \frac{X}{X_{-1}} - 1 \right],
\]

(3')

\(3.938 \quad (4.027)\)

Adjusted \(R^2 = 0.559 \quad \text{D.W.} = 1.609 \quad \text{Period: 1982-1994.}\)

The numbers in the parentheses are \(t\) statistics.

The coefficient in the second term (\(\theta_2\)) of Equation (3)'', is highly significant statistically, suggesting labor-hoarding in the investment sector of the economy as the source of procyclical movement of labor productivity. Although \(\theta_2\) estimate (0.792) is large, the below-unity value implies that the investment goods industry would still have to add substantial numbers of workers to increase output.

The wage and household consumption goods demand functions, (5) and (6), are estimated jointly. See Table 2-I for the estimated wage function, here called (5)'. The estimated household consumption goods demand function (6)' has a positive coefficient for the increment of
incomes, as anticipated.

\[ \Delta Q = 0.723 \Delta \frac{G}{P}, \]
\[ (11.675) \]
\[ R^2 = 0.993 \quad D.W. = 1.625. \]

**Long-run Rate of Inflation**

The coefficient estimates of (5)' allow one to compute the approximate long-run rate of inflation in reform-period China. Because long-run growth depends solely on the expansion of productive capacity, the demand-side factors for inflation need not be considered. The Leontief or Cobb-Douglas production function yields the rate of inflation function (10)\(^6\),

\[ \left[ \frac{P}{P_{-1}} - 1 \right] = \left[ \frac{W}{W_{-1}} - 1 \right] - \left[ \frac{V}{V_{-1}} - 1 \right]. \]  
(10)

Equation (11) can be obtained by solving (10) for the growth rate of the wage, substituting this into (5), and then solving the new equation for the rate of inflation,

\[ \left[ \frac{P}{P_{-1}} - 1 \right] = \left[ \frac{\lambda_2 - 1}{1 - \lambda_1} \right] \left[ \frac{V}{V_{-1}} - 1 \right]. \]  
(11)

The peculiar mode of wage determination in China's reform period implies that the long-run rate of inflation depends positively on the growth rate of labor productivity according to equation (11). The value of the multiplicative term on the right-hand side is 1.402 based on the estimates of \( \lambda \)s (Table 2-I). Because the mean growth rate of labor
productivity in the 1979-1992 period was 6.0 percent, Equation (11) yields 8.4 percent as the long-run rate of inflation. The computed value is somewhat higher than the actual mean growth rate of the consumption goods price index for the period, 6.0 percent.\textsuperscript{17}

5. DYNAMIC SIMULATION

Because the causality running from output and fixed investment to the price level in the model is complex, I derive the growth-inflation tradeoff with dynamic simulation instead of solving the model for the consumption goods price. Let us trace the gist of the underlying relationship in the model. A rise in fixed investment leads to higher labor productivity (through 3) and employment (by augmenting the value in the bracket in 4). High productivity further brings about wage hikes through (5). Because nominal household incomes grow as a result of increases in employment and the nominal wage, the consumption goods price must rise to clear the market. The price, the wage, and nominal household incomes move together in this process on account of simultaneity. The initial impact on the price is magnified as the wage adjusts successively to new price levels. Because fixed investment (output of the investment goods industry) is a component of output, high output and the high consumption goods price are linked in this economy. As fixed investment fluctuates widely, we should observe a short-run growth-inflation tradeoff.

Simulation Setup

Upon running dynamic simulations of the eight-equation model, estimated coefficients are inserted in the respective equations. The starting values of lagged endogenous variables and the interest rate (r) are those of 1978 values. The following assumptions are made in equation (1): (i) $\delta_0$ to $\delta_4$ are, respectively, 0.1, 0.3, 0.3, 0.2,
0.1; and (ii) the values of \( \gamma \) and \( \delta \) are 0.5 and 0.05. Using these values and assuming the capital stock in 1956 to have been 100 billion yuan in 1978 prices, the time series of capital stock up to 1979 has been reconstructed with state fixed investment data based on equation (1). The initial capital stock of the consumption goods industry for the simulation follows the computed 1978 value (271.3 billion yuan). Using the computed 1979 capital stock value and actual consumption goods output in 1979, \( \beta \) (0.506) is obtained as the reciprocal of the capital-output ratio that year. Considering that part of the money held by households is currency, the value of \( r \) (0.046) is set to two-thirds of the mean nominal interest rate of one-year savings deposits in the 1979-1992 period.

The lagged values of fixed investment \( (x) \) in (1) in the starting year follow those of state fixed investment from 1975 to 1978. The time series of \( x \) is extended for 15 years from the 1978 value using a series of growth rates generated randomly. The mean of the growth rate generated follows the arithmetic-mean growth rate of state fixed investment for the 1979-1992 period (10.6 percent). The standard deviation of the growth rate generated follows that of the total fixed investment for the 1982-1994 period (11.7 percent). Two separate series of fixed investment are referred to, because the data for the more comprehensive of the two, total fixed investment, are available for a shorter period (from 1981). The supply shock term for the consumption goods industry \( (\alpha) \) is represented by a generated series of a random variable whose mean and standard deviation are unity and 0.025. The standard deviation of the growth rate of personal consumption for the 1979-1992 period is 3.7 percent (Table 1). I have assumed that 2.5 out of the 3.7 percent deviation is attributed to random supply shocks.

Simulation

For the first simulation, Case 1, the random supply shocks in the
consumption goods industry are suppressed (\( \alpha \) is set to unity). Simulation is run for 17 years. The first year observations are set aside, because there are some leaps in endogenous variables at the outset. Accordingly, the second and third years are labelled as Years 0 and 1 and the 17th as Year 15. The simulated growth rates of five variables (GMP, \( Y \); the consumption goods price, \( P \); consumption goods output, \( Q \); the nominal wage, \( W \); and labor productivity, \( V \)) in Cases 1 and 2 are reported in Table 3. Also listed are the two exogenous variables, the growth rate of fixed investment (\( x \)) and the percentage deviation of the random shock term (\( \alpha \); Case 2 only). The mean growth rates of the five endogenous variables in Case 1 do not appear to be distant from those of corresponding variables in the 1979-1992 period listed at the bottom (\( Y \) for real GDP, \( P \) for CGPI, \( Q \) for personal consumption, \( W \) for nominal wage, and \( V \) for labor productivity from Table 1). The growth rates of GMP and the consumption goods price are 9.0 and 8.5 percent, while their values in the 1979-1992 period are 9.0 and 6.0 percent. The standard deviations of the five variables in Case 1 fall largely around those in the 1979-1992 period, except for the consumption goods output.

For Case 2, the random shock term (\( \alpha \)) in the consumption goods industry is reinstated to consider the inflationary impact of random supply shocks. As a result, the standard deviation of the growth rate of consumption goods output (\( Q \)) rises from 1.7 in Case 1 to 4.5. The behavior of the other four variables listed is largely similar.

**Implied Tradeoff**

To derive the growth-inflation tradeoff from the simulated paths, the equation for the rate of inflation is estimated by OLS with simulated growth rate values for the 15-year period. The dependent
### Table 3
SIMULATED PATHS

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<th>Q</th>
<th>W</th>
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Mean 9.0 8.5 8.0 16.3 7.2 10.9
SD 3.3 8.0 1.7 8.2 2.4 8.8

Case 2

Mean 8.9 8.7 7.8 16.3 7.1
SD 4.2 8.3 4.5 7.9 2.7 2.8

### Corresponding values, 1979-1992

Mean 9.0 6.0 8.4 14.5 6.0
SD 3.4 5.7 3.7 6.9 3.2

Note. Mean is the geometric-mean growth rate. SD is the standard deviation of the growth rate.
and the independent variables are a constant and either the growth rate of GMP (Y) or fixed investment (x). Table 4 shows that the estimated coefficients of the two growth rate variables have correct signs (positive) and are significant statistically at either the 1 or 10 percent levels in all five equations. This suggests the presence of the tradeoff given the structure of the current Chinese economy. The estimation confirms that the inclusion of the random supply shocks in Case 2 lowers markedly the statistical significance of the coefficients. The t statistics of the coefficients fall from 34.541 in 1-I to 1.779 in 2-I for the growth rate of GMP and from 45.462 in 1-II to 8.464 in 2-II for the growth rate of fixed investment.

I am inclined to think that supply shocks together with random errors in the structural equations (the latter are omitted in the simulation) are capable of concealing the underlying tradeoff. Take an adverse supply shock for instance. Bringing about low output and high prices, it does not lead to a tradeoff. I have estimated the same rate of inflation equations by OLS with the reform period data. The growth-inflation tradeoff is not confirmed with these data.18

To consider whether the growth of fixed investment has a lagged effect on the prices, an equation with the previous year’s growth rate of fixed investment is estimated (1-III). The coefficient of the lagged term has a very small value (0.028) with a low level of significance (t statistic, 1.272). This suggests that such carry-over effect of fixed investment on prices is negligible.

Controlling for random supply shocks, the estimated coefficients under Case 1 represent the magnitude of the underlying growth-inflation tradeoff driven by the fluctuation of fixed investment. The estimated coefficient of the growth rate of GMP in 1-I is 2.653, implying that economic growth one percentage point higher in a given year brings about approximately a 2.7 percent increase in the rate of inflation variable is the growth rate of the consumption goods price index (P),
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<th>Case 2</th>
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<td>1-II</td>
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<tr>
<td>Period: Year 1-15</td>
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<tr>
<td>Constant</td>
<td>-16.033** (-5.290)</td>
<td>-1.481** (-5.251)</td>
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<tr>
<td>Y’s growth, %</td>
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<tr>
<td>x’s growth, %</td>
<td></td>
<td>0.909** (45.462)</td>
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<tr>
<td>x_{t-1}’s growth, %</td>
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<td>Rho</td>
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<td>D.W.</td>
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Note. The numbers in the parentheses are t statistics. * and ** indicate statistically significant at the 10% and 1% levels. a, the sample period is Year 2-15.
that year. The coefficient of the growth rate of fixed investment in 1-II is 0.909, implying that one percentage point higher investment growth adds about 0.9 percent to the rate of inflation. The ratio of the two coefficients, 0.909/2.653 or 0.343, comes from the mean fixed investment share of GMP.

Past economic cycles in China have mainly been led by investment cycles. Planners appear to have exploited the growth-inflation tradeoff by letting fixed investment grow rapidly when the rate of inflation is low [Imai, 1994, p. 207]. Because the peculiarities of the labor market and the mode of wage determination in China preclude the wage-price dynamics that follows the accelerationist hypothesis, can planners in China trade permanently a high but constant rate of inflation for a high economic growth rate propelled by investment expansion? This is essentially the same as asking the feasibility of an inflation tax for the goal of rapid industrialization. High economic growth in China may not lead to a shortage of workers for some time to come because of a large labor surplus. Nevertheless, it is most unlikely that a high-investment/high-inflation growth strategy, if carried out for an extended period, would not face increasing resistance from the working population. The presence of excess workers does not prevent falling government popularity and work morale from compelling planners to award workers higher wages sooner or later. Such a conjecture leads one to conclude that the implied tradeoff in China is not incompatible with some nullification mechanism in a longer time frame. The tradeoff is contingent on planners' prudence in operating within the "tolerance limits" (Kornai 1992, p. 168) of the public.

6. CONCLUSION

The rate of inflation in China has behaved cyclically and two inflationary spells have appeared in the past decade. I have
investigated the short-run inflation dynamics in the reform period to derive numerically the growth-inflation tradeoff. The high growth and wide fluctuations of fixed investment appear to be the main driving forces of the rate of inflation. The other two demand-side causes commonly cited, the fast growth of household incomes and of money supply, are related to fixed investment and generally follow investment expansion. The tight supply of agricultural products constrains the consumption goods market and leaves it susceptible to demand pressures associated with the rapid increase of household incomes. Also the prevailing mode of wage determination in China has an element of the cost-of-living adjustment, and it generally gives a link between nominal wages and labor productivity, in which the former is allowed to grow more than proportionally to the latter. Under these circumstances, investment expansion generates strong demand pressures in the consumption goods market, and its inflationary impact is magnified further as it brings about higher wage costs.

I have constructed a macroeconomic model, estimated structural equations, and performed dynamic simulation. The implied short-run tradeoff derived is that in a given year, each additional percentage point of economic growth or investment growth leads to, respectively, a 2.7 or a 0.9 percent increase in the rate of inflation that year. The estimated wage function does not confirm the wage-price relationship that follows the accelerationist hypothesis in China. This, however, may not suggest the presence of a permanent growth-inflation tradeoff, which planners can exploit, because other mechanisms to nullify it may exist.

Despite institutional differences, the Chinese government is facing basically the same kind of short-run macroeconomic tradeoff common in market economies. Nevertheless, a large part of China's inflationary pressures in the reform period comes from two behavioral peculiarities of the state sector in systemic transition: high growth
of fixed investment and wage payments in state enterprises. Because these can be controlled if the government privatizes state enterprises or imposes strict financial accountability on them, the nature of inflation may change as economic reforms proceed further.
REFERENCES


State Statistical Bureau, "Communique on 1994 National Economic and


APPENDIX

Sources of Data

G  (nominal household incomes) sum of $Q$ and $\Delta M$. This is an estimate of total household cash incomes.

M  (nominal money supply) sum of currency and savings deposits held by households. Zhongguo shichang tongji nianjian, p. 182.

P  (price of consumption goods) consumption goods price index in the retail price index (base year: 1978, 1978 level = 100) is divided by 100. Zhongguo tongji nianjian 1994, p. 235. The 1994 index is obtained by extending the series with the growth rate of the retail price index reported in the State Statistical Bureau's Communique (1995, p. V).

Q  (output of consumption goods) sum of nominal value of household expenditures for consumption goods (Zhongguo tongji nianjian 1993, p. 611) and services (Zhongguo tongji nianjian 1986, p. 443, 1991 ed., p. 582, and 1993 ed., p. 602) is divided by $P$.

r  (interest rate on money held by households) mean interest rate on one-year savings deposits (Zhongguo jinrong nianjian, p. 385). The starting value for the simulation is 0.026, two-thirds of the mean interest rate on one-year savings deposits in 1978.

V  (labor productivity) GDP in 1978 prices in $Y$ is divided by the number of employed (Zhongguo tongji nianjian 1994, p. 97). The starting value for the simulation is the sum of $Q$ and state fixed investment divided by the number of employed in 1978.

W  (nominal annual wage) $G$ net of interest incomes (total
household earned cash incomes) is divided by the number of employed. Interest incomes are the product of savings deposits balances at the end of the previous year and \( r \) in the previous year.


NOTES

1. I thank Kazunari Shimpo and Mark Wheeler for their comments and suggestions on estimation procedures. In addition, I am grateful to Harvard University's Fairbank Center for East Asian Research, where I wrote the draft.

2. Because GDP data are available only from 1978, the growth rates cited are based on the net material product (NMP) index to compare the two periods (1979-1993 and 1955-1978). Sources: Zhongguo tongji nianjian 1993, p. 34 and the 1994 edition, p. 34.

3. The consumption goods price index (CGPI) comprises the retail prices of consumption goods after excluding agricultural producers' goods from the general retail price index (GRPI). The year-to-year growth rate of GRPI is the most commonly used measure of the rate of inflation in China. The weights of the CGPI and GRPI are based on retail value. [Ma, 1982, pp. 495-496]. The numbers cited are for the 1979-1994 and 1955-1978 periods. See Appendix (under P) for the sources.

4. For the two explanations and how they have been used in the monetary policy debate during the current U.S. boom, see three New York Times articles in 1994 by Bradsher, Nasar, and Uchitelle. Also Frisch (1983) offers a formal treatment of the Phillips curves. Bradsher reports, "When experts like Mr. Greenspan estimate the economy's fastest sustainable growth at full capacity to be about 2.5 percent, they are adding together annual productivity gains of about 1.5 percent and annual increases in the labor force of 1 percent or so" and "Federal Reserve officials are concerned that growth in the coming years may consistently exceed 2.5 percent, their best estimate of the economy's speed limit at full capacity. Break the speed limit for too long, and sooner or later the penalty will be inflation, they warn."

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5. Tian (1986, pp. IX-X) acknowledges "the problems of inordinate price increases" in 1985, and the Party and the government have begun strengthening "overall control over the scope of capital investment and consumer funds" to eliminate "destabilizing factors from the national economy." Commenting on the rising rate of inflation in 1988, Liu (1988, p. 14) states: "From 1984 to 1987, the money supply grew at a far greater rate than actual economic growth, leading to devaluation and price hikes" and "at the same time, there has been a large expansion in demand for investment and consumption, stemming from the impulse to pursue high-speed growth." Li (1995, p. III) attributes the high rate of inflation in 1994 to "objective reasons and to mistakes of governments at all levels." Along with (i) poorly planned and managed hikes in official prices and price decontrol of grain, cotton, crude oil and others and (ii) short supply of agricultural products partially associated with crop damage on account of natural calamities, Li points out demand-side factors: "There had been a rapid growth of investment in fixed assets and consumption funds, and too much currency had been put into circulation for several years running. The government took no emergency measures to stop these practices..., in order to prevent a sharp decrease in economic growth, but thereby the difficulty in curbing price rises increased."

6. Food made up 54.9 percent of consumption goods sales in 1993 (Zhongguo tongji nianjian 1994, p. 498). Also, a substantial proportion of non-food consumption goods use materials of agricultural origin.

7. For the government’s policies on food prices and rationing in the reform period, see Wiemer and Lu (1993).

8. Perkins cautions that this system may lead to "a price spiral caused by a combination of excess demand and cost-push pressures": "In the Chinese case, it is probably more realistic to expect that the monetary authorities will lack the political independence needed to hold the line on monetary expansion. In that case credit will expand rapidly,
prices will rise, enterprises will raise wages to keep workers from being hurt by inflation, which will increase demand further and lead to more increases in prices" (1991, p. 164). The reinforcing mechanism implied here, which goes with a demand inflation through wage hikes intended to compensate the increased cost of living, is discussed in the text below. Naughton explains why and how the weakness of the state banking system makes macroeconomic management ineffective and inflation control difficult in a more general context (1991, pp. 153-158).

9. The details of wage reform measures in this paragraph are from Hu and Li (1993).

10. Walder cites a few examples. Enterprises whose profits fall short of targets or run a temporary deficit can still pay out substantial bonuses if managers can convince the supervisory authorities that the losses are due to objective factors (1987, p. 35). Objective factors can be anything beyond the direct control of the enterprise manager such as "price rises that unexpectedly increase the costs of production, supply shortages, old and worn out capital equipment, changes in state foreign-trade policy that affect the enterprise, and low state prices for products" (1989, p. 258). Enterprises often keep covert cash reserves to use for bonuses, generated through various violations of accounting rules (1987, p. 37).

11. According to Gu (1995), excess workers in the urban state sector numbered about 30 million out of a total of 109 million workers in a recent period. He mentioned that in some state enterprises as many as half of the workers were redundant.

12. State sector workers are paid cost-of-living allowances and subsidies in order to offset price rises. According to a household survey in July 1988 cited by Hu and Li (1993, p. 166), these allowances and subsidies made up 18 percent of the total household wages of staff and workers. Note that enterprises, out of a wish to protect workers' interests, may award high wages in reaction to a rise in the rate of
inflation in addition to increasing cost-of-living allowances.

13. Current financial difficulties of state enterprises, however, may weaken workers' bargaining position in the future. For example, from around 1994, enterprises began to relieve part of employees from work for an extended period with reduced wages. The number of these workers in virtual layoff in state enterprises was reported as about 3 million in mid-1995 (Renmin Ribao, June 15, 1995). Also, the government has begun to increase gradually the number of closures of state enterprise in deficits. The government is reluctant to bear the increasing financial burden to support state enterprises partly because of the deterioration of state banks' asset quality and the inflationary impact of loan expansion.

14. The consumption function by Campbell and Mankiw admits two groups of consumers, one group spending rationally following the permanent income hypothesis and the other acting myopically by spending all current income. μ represents the income share of the myopic consumers (pp. 186-190).

15. The table below shows the structure of the eight-equation version of the model.

<table>
<thead>
<tr>
<th>Equation number</th>
<th>Endogenous variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>K V Q G W P M Y</td>
</tr>
<tr>
<td>(3)</td>
<td>x x x x x x x x x</td>
</tr>
<tr>
<td>(2)</td>
<td>o o o o o o o o o o x</td>
</tr>
<tr>
<td>(4)</td>
<td>o o o o o o o o o o</td>
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<tr>
<td>(5)</td>
<td>o o o o o o o o o</td>
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<td>(6)</td>
<td>o o o o o o o o o</td>
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<tr>
<td>(8)</td>
<td>o o o o o o o o o</td>
</tr>
<tr>
<td>(9)</td>
<td>o o o o o o o o o</td>
</tr>
</tbody>
</table>

x and o denote, respectively, endogenous variables that are associated with the equations and other endogenous variables that appear in the equations. Roman numerals in the right column indicate the order of iteration. III is a block of three simultaneous equations.

16. For the derivation of the function, see Branson (1989, p. 484).
17. Note that Equation (10) assumes a single industry in the economy. The macroeconomic model in this paper has two industries (consumption and investment goods) and the rate of inflation is based on the price of consumption goods. The long-run rate of inflation obtained from equation (11) therefore may deviate from that based on the consumption goods price index.

18. The dependent variable of the estimation equations is the growth rate of the consumption goods price index. Two OLS regressions have been run separately with either the growth rate of GDP (for the 1979-1994 period) or of total fixed investment (for the 1982-1994 period) as an explanatory variable along with a constant. Neither of the two estimated equations yields a meaningful relationship. The coefficients of the two growth rates had t statistics below unity and adjusted $R^2$ were close to zero.