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Abstract

Deflationary expansion has puzzled economists both in and outside China. We study this business cycles phenomenon within a model of discrete time dynamics. We find that deflationary expansion could be possible if driven by an overshooting in investment and if the state of the economy maintains high rate of growth. This expression is consistent with the recent time series variation of some key macroeconomic variables. The high steady state of growth could be explained by the current institutional environment of China.

JEL: C62, E32, E50 and P24

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1 Introduction

China has experienced remarkably high growth since its economic reform started at 1978. The annual growth rate of real GDP has been, on average, 9.4% over the last 25 years (1979-2003). Despite this high growth, China's economy has also exhibited a significant cyclical pattern. The most recent cycle started from 1990 when the economy reached a low point. The growth rate in that year was 3.8%, which was the lowest since economic reform began. The economy started its recovery in 1991. It was then followed by 3 consecutive years of peak with the growth rate all over 12%. This extraordinary growth also brought 3 consecutive years (starting with 1993) of accelerating inflation all over 13%. The economy was then followed by prolonged contraction (until 2003) during which both the growth rate and inflation rate declined in tandem (see Panel a and b in Figure 1).[1] One of the notable remarks on the recent cycle is that during the contraction period when the economy was even in deflation, the growth rate had still been high (about 7%) compared to the contemporary world economy.

Such a high growth rate with deflation has puzzled many economists. Chinese economists have named this "deflationary expansion". Various disputes have been made among Chinese economists on solving this puzzle. Some economists outside China even doubt the reliability of statistics officially published.[2] An appropriate expression seems to be necessary to explain why China can experience deflationary expansion.

According to typical economic theory, deflationary expansion could be possible if there is a strong positive supply shock, such as productivity growth.[3] In contrast to the negative supply shock, a positive supply shock will cause the aggregate supply curve to move to the right. Given the aggregate demand curve, this indicates that the output will increase while the price can be reduced. This opinion is held by some economists in China. Although we believe that China's economic reform does raise productivity, which could be regarded as a positive supply shock, the process should be gradual due to the pattern of gradual economic reform in China. Indeed, we hardly observe a significant instance in the Chinese economy that can be regarded as a strong positive supply shock within that period.

An alternative explanation is from Lin (2000, 2004), according to which deflation is caused by over-investment in the preceding years. Over-investment

[1] The data in Figure 1 is obtained as follows: the inflation rate and the growth rates in GDP and in investment are obtained from the National Bureau of Statistics of China (2004). The capacity utilization is computed by Gong and Yang (2002).

[2] See, for instance, Rawski (2002).

[3] See for instance Bordo and Lane (2004)

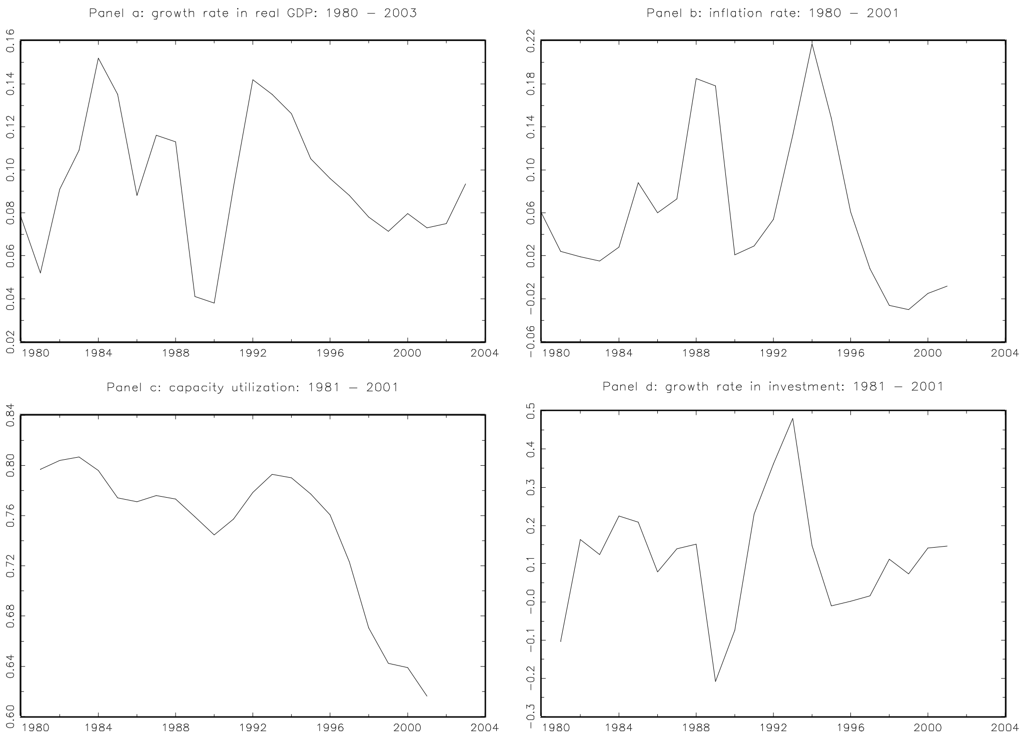

Figure 1: Some Time Series Variations in the Recent Chinese Economy

not only creates excess demand, but also accumulates a huge amount of capacity. While demand can be created relatively fast, the accumulation of capacity might be gradual. This indicates that the first impact of over-investment is to accelerate inflation. Thus, when the government conducted an anti-inflation policy via demand management, the consequence was excess capacity, which brought the deflation (see Panel c and d in Figure 1 for the time series variation of capacity utilization and the growth rate of investment).

The idea of over-investment can be formulated in a dynamic model, which will be constructed later in this paper. It is consistent with the overshooting perspective as often discussed in business cycles theorem. It is well known that when the eigenvalues of a dynamic system are complex conjugate, a small shock may generate large and even persistent fluctuation. Thus, deflation could be possible when there is over-investment.

The overshooting perspective (in investment) may explain the problem of deflation as has occurred recently in the Chinese economy. It does not provide an explanation, however, why the economy can still grow at a relatively high rate even if it is in recession. Yet, in a dynamic system, as we construct in this paper, this could be possible if the steady state growth rate is high. This seems to be not in contrast to the observation that the growth rate (about 7%) in the recession era of China was not only significantly lower than the preceding years, but also below the average growth rate (about 9.4%) over the last 25 years. For a more satisfying explanation of "deflationary expansion", we therefore must also understand how China has generally grown at a relatively high rate throughout economic reform.

In section 2, we shall first discuss briefly the institutional environment of China since economic reform. This discussion not only provides a background for the followed dynamic model, but also allows us to understand why China can grow at a high rate over most of the past 20 plus years. In section 3, we construct a model of investment under the current credit allocation system of China. To some extent, the discussion in this section may be viewed as a behavior analysis of the investment function, the key behavior function in our dynamic system that will be presented in section 4. A statistical analysis will also be conducted in section 4 to estimate some behavior functions as appearing in the dynamic system. Section 5 provides an analysis both analytically and numerically of our dynamic system. This analysis will allow us to see how an overshooting in investment can generate deflation following accelerating inflation. Finally section 6 concludes.

2 Institutional Environment

One of the observations since World War II is the convergence in per capita GDP within a certain group of economies. The convergence hypothesis indicates that the countries with low per capita GDP can grow at a higher rate and will eventually converge with those with high per capita GDP within the group. Many articles have tested the convergence hypothesis and tried to explain the convergence.[4] It has been argued that the countries who experienced convergence may be subject to certain institutional environments. Although it is not totally clear what these institutional environments could be, the stable political system, no significant upheaval and revolution seems to be required. This institutional environment seems to have existed in China over the last 20 plus years. The stable political environment has made it possible for the country to focus its effort on economic development. This is particularly in contrast to the Cultural Revolution and other political upheaval that had continuously occurred in the past. Of course, a stable political environment is not sufficient enough for a country to reach convergence. This section will discuss some economic environment that may help to understand how China can grow on average at a higher rate since the economic reform. Our discussion will be focused on the key economic premise that China is not only a transition economy but also a developing economy.

2.1 Dual Structure

Since economic reform started in 1978, China has undergone substantial decentralization. This decentralization can be understood in two respects. First, the government has abandoned the previous central planning system and has given autonomy to state-owned enterprises in deciding their price and quantity in most non-financial sectors (Naughton, 1995). Second, decentralization has also allowed the rapid growth of non-state enterprises in many competitive industries. This decentralization process made the Chinese economy more market oriented and economic resources more efficiently allocated. One of the achievements in the efficiency of resource allocation is to free the huge amount of surplus labor in the rural areas of China.

The dual structure in rural and urban areas is an obvious feature of developing economy of China. In rural areas, each family is endowed with a piece of land that may sustain the family's living but at a very low level compared to the standard of living in urban areas. Since the land for each family is extremely limited, there is an enormous surplus of labor in the rural

[4] See Barro and Sala-i-Martin (1991, 1992).

areas of China. Economic reform and the emergence of a large amount of non state-owned enterprises has allowed the labor surplus in rural areas to move into urban areas as has been occurring in the past. Since the labor surplus in rural areas is so huge, the labor market in city has always been in over-supplied. This further indicates that wages in urban areas is not sensitive to the labor market, but only to inflation and productivity.[5] We should note that this developing feature of the Chinese economy is exactly what Lewis, a Nobel laureate in 1979, described in his seminal paper on developing economics (see Lewis 1954).

The existence of a dual structure has an important implication in explaining China's economic growth. As many have argued, the major driving force of high growth in China is the high growth in investment.[6] The high growth in investment creates not only fast accumulation of capacity but also high growth in demand. Fast accumulation of capacity requires the absorption of more people to work in urban areas. Therefore, high growth in investment is not possible without sufficient labor surplus.

2.2 Credit Plan

High growth in investment is also not possible without sufficient financial resources. In contrast to most OECD countries, the major financial resource for investment in China is credit. In past years, the monetary authority in China has set up a yearly target growth rate in the money supply, M1 and M2. Once the target has been set up, the monetary authority will employ the credit plan as its principle instrument to implement the target.

In each year's credit plan, the state banks are given credit quotas, which can be regarded as the target on the amount they could and should lend in total for investment and other purposes. Sometimes the credit quotas are given along with a variety of details with respect to the provinces, industries and state and non-state firms. Although in most cases the credit plan is only indicative under which the state banks were given some discretion over their lending activities, occasionally the government resorts to using administrative mechanisms to implement the credit plan.[7]

The credit supply in China can be regarded as being cheap and easy. Such cheap and easy credit can be observed from several statistics. As we can find in Table 1, the average real interest rate in loan supply is about 2% in China, much lower than other OECD countries. In the same time,

[5]This will be verified in our estimation of wage equation (see section 4).

[6]See Lin (2000), Lin, Cai and Zhou (2003) and Brandt and Zhu (2000, 2001)

[7]In the view of Brandt and Zhu (2000) and (2001), it is the alteration of indicative and administrative credit plan that generates the business cycles.

the average growth rate of the money supply is about 20%, which is not only much higher than the level of OECD countries (about 6-7%), but also significantly higher than the nominal growth rate (about 16%) of GDP in China. We shall also remark that while the growth rate of the money supply is so high, the state banks are also suffering huge amount of non-performing loans.

Table 1: Credit Comparison: China and Some OECD Countries[8]

	China	U.S.	Germany	France.
real interest rate (%)	2.1418 (1980−2001)	3.4757 (1964−2003)	4.1092 (1970−2003)	4.5654 (1980−2003)
growth rate of money supply	0.2006 (1985−2001)	0.0712 (1964−2003)	0.0626 (1975−2003)	0.0601 (1980−2003)
growth rate in nominal GDP	0.1606 (1981−2001)	0.0725 (1964−2003)	0.0564 (1970−2003)	0.0619 (1980−2003)

The easy and cheap credit provided by the government via its state banking system is certainly an important transitional feature of the Chinese economy. It reflects the strong intention of government to use its monetary policy to promote economic growth in addition to usual demand management.

Of course, there are many other important reasons that may also help us to understand the high growth of the Chinese economy. A more sufficient discussion is important and certainly desirable. In this paper, we, however, focus on the business cycle aspect of the Chinese economy, especially the recent cycle of deflationary expansion. For this purpose, all we need to assume is that China's economic reform since 1978 has given China the energy to grow at a high rate. In a dynamic business cycle model as being formulated in section 4, this indicates a higher steady state growth rate. In addition for us to understand high growth, the recognition on the dual structure and the credit allocation system in the Chinese economy will also help us to formulate our dynamic business cycle model.

3 A Model of Investment with Credit Allocation

In this section, we shall construct a model of investment under the credit allocation of the current banking system in China. To some extent, this section might be regarded as a behavior discussion on the investment function, the key behavior function in our dynamic business cycle model.

[8]The data for U.S., Germany and France comes from OECD (2004). The data for China comes from National Bureau of Statistics of China (2004).

3.1 Investment without Credit Constraint

Our first task is to discuss investment without credit (or other financial) constraint. For this purpose, we shall first establish a proposition regarding an existence of optimum capacity utilization which a firm wants to achieve via its investment. We derive this proposition using an intertemporary dynamic optimization model as described below.

In standard microeconomic theory, there are two types of costs occurring in a firm's production: one is fixed cost and the other is variable cost. Generally, the average cost decline is first due to the large amount of fixed cost and then increases when the production approaches capacity. This standard theory is for a firm's production in which the capacity is assumed to be given. In a theory with firm's investment, it is perhaps not valid to assume a fixed cost since what we are considering is to change the capacity. We assume that in this case the average cost is a non-decreasing function of capacity utilization U.[9]

Given this assumption, we consider a representative firm indexed by i, $i = 1, 2, ..., n$, whose cost function in period t can be written as

$$C_{i,t} = c_i(U_{i,t})Y_{i,t}, \quad c_i' \geq 0 \tag{1}$$

where $C_{i,t}$ is the total cost for firm i in period t; c_i is the average cost, which is a function of capacity utilization $U_{i,t}$; $Y_{i,t}$ is the output measured in monetary units.[10] In particular, we can write $U_{i,t}$ as

$$U_{i,t} = \frac{Y_{i,t}}{A_i K_{i,t}} \tag{2}$$

where $K_{i,t}$ is the capital stock, and A_i is the technology. Given this cost function as expressed in (1), the firm's profit denoted as $\pi_{i,t}$ can be written as

$$\pi_{i,t} = Y_{i,t} - c_i\left(\frac{Y_{i,t}}{A_i K_{i,t}}\right)Y_{i,t} - I_{i,t}$$

where $I_{i,t}$ is the investment.

Investment is constructed for future capacity and therefore we shall assume that the firm has been given a sequence of expected demand $E\left\{Y_{i,t+j}\right\}_{j=0}^{\infty}$ when making an investment decision in period t. The problem of investment can thus be expressed as a sequence of investment $\{I_{i,t+j}\}_{j=0}^{\infty}$ such that

[9] We should note that whether the average cost is a decreasing or increasing function of capacity utilization is not important, as will become clear, for deriving our basic proposition: the existence of optimum capacity utilization.

[10] so that it may be regarded as a revenue from the sale. This indicates that the price is expected to be fixed when the firm makes an investment decision.

$$\max_{\{I_{i,t+j}\}_{j=0}^{\infty}} E \sum_{j=0}^{\infty} \beta^j \left[Y_{i,t+j} - c_i \left(\frac{Y_{i,t+j}}{A_i K_{i,t+j}} \right) Y_{i,t+j} - I_{i,t+j} \right] \tag{3}$$

subject to

$$K_{i,t+j} = (1 - d_i) K_{i,t+j-1} + I_{i,t+j} \tag{4}$$

where E is the expectation operator; β is the discount factor and d_i is the depreciation rate. Apparently, (4) can be regarded as the equation of capital accumulation. Note that although the decision here appears to be a sequence $\{I_{i,t+j}\}_{j=0}^{\infty}$ only the investment in period t, $I_{i,t}$, is implemented in t.

The Euler equation for this optimization problem (3) and (4) can be written as

$$E \left[Y_{i,t+j} \frac{Y_{i,t+j}}{A_i K_{i,t+j}^2} c_i' \left(\frac{Y_{i,t+j}}{A_i K_{i,t+j}} \right) \right] + \beta(1 - d_i) - 1 = 0$$

Using (2) to express $Y_{i,t+j}/K_{i,t+j}$, we obtain from the above

$$E \left[U_{i,t+j}^2 c_i' \left(U_{i,t+j} \right) \right] = \frac{1}{A_i} \left[1 - \beta(1 - d_i) \right] \tag{5}$$

Equation (5) above allows us to derive the optimum capacity utilization. Since the right side of the equation is composed of parameters, we find that the optimum capacity utilization denoted as U_i^* should be time invariant.[11] Also note that if the cost function and the parameters of technology and depreciation rate are invariant across all i's, the optimum capacity utilization U_i^* should also be invariant across all firms. This identical assumption, which is very common in representative agent models, will also be applied later to simplify our analysis.

Given the existence of such optimum capacity utilization denoted as U_i^*, we shall now discuss how investment should be made. Since the investment is made to achieve the optimum U_i^*, the optimum investment in period t, denoted as $I_{i,t}^*$, should satisfy

$$\frac{EY_{i,t}}{A_i \left[(1 - d_i) K_{i,t-1} + I_{i,t}^* \right]} = U_i^*$$

where the left side of the above equation is the expected capacity utilization. From this equation, we obtain

$$I_{i,t}^* = \frac{1}{A_i U_i^*} EY_{i,t} - (1 - d_i) K_{i,t-1} \tag{6}$$

[11] although there may exist multiple solutions.

3.2 Investment under the Credit Constraint

We now introduce the credit constraint into the model. Let us first consider the interest rate in the Chinese economy. As we have discussed earlier, the real interest rate in China is generally at a low level compared to OECD countries. In the same time, the soft-budget constraint is also to various degrees a property of China enterprises. This indicates that the interest rate may not be considered as an effective constraint on investment, that is, making the investment deviate significantly from the optimum level as expressed in (6). Only the quantity constraint or the credit constraint that may affect the investment.

Consider now that our representative firm is able to acquire a loan up to $\Delta M_{i,t}$ for its investment from a state owned commercial bank. We know that the firm's investment will be $I^*_{i,t}$ as expressed in (6) if the firm is not subject to the credit constraint. This indicates that the firm's investment under credit constraint can be written as

$$I_{i,t} = \begin{cases} I^*_{i,t} & I^*_{i,t} < \Delta M_{i,t} \\ \Delta M_{i,t} & I^*_{i,t} \geq \Delta M_{i,t} \end{cases} \tag{7}$$

Let ΔM_t denote the target growth of monetary base and therefore the total amount of credit that can be generated from ΔM_t is $(\gamma - 1)\Delta M_t$, where $\gamma > 1$ is the money multiplier. This is the amount of money that the state bank can lend out to finance the investment.

Consider now a credit allocation under the discretion of state bank (or under the guideline of credit plan via administration): $\{\Delta M_{i,t}\}_{i=1}^n$, where

$$\Delta M_{i,t} = l_i(\gamma - 1)\Delta M_t \tag{8}$$

with $l(i) \in [0, 1)$. Under this credit plan, the firm makes their decisions of investment as formulated in (6)-(8). Summing up all $I_{i,t}$'s, we get the aggregate investment I_t:

$$I_t = \sum_{i=1}^{n} I_{i,t} \tag{9}$$

Depending on the credit ratio $l(i)$ the firm was assigned, we find that for some i's investments are bounded, that is, $I_{i,t} = \Delta M_{i,t}$; for the others, investments are optimum, that is, $I_{i,t} = I^*_{i,t}$. Re-arranging the index of the firm such that the first n_1 firms are bounded, we therefore can rewrite (9) as

$$I_t = \phi \Delta M_t + \sum_{i=n_1+1}^{n-n_1} \left[\frac{1}{A_i U_i^*} EY_{i,t} - (1 - d_i)K_{i,t-1} \right] \tag{10}$$

where

$$\phi = (\gamma - 1) \sum_{i=1}^{n_1} l_i > 0$$

Under the identical assumption as we have mentioned earlier, we may denote U_i^*, A_i and d_i as U^*, A and d respectively for all i's. This then allows us to rewrite (10) as

$$I_t = \phi \Delta M_t + \frac{1}{AU^*} \sum_{i=n_1+1}^{n-n_1} EY_{i,t} - (1-d) \sum_{i=n_1+1}^{n-n_1} K_{i,t-1}$$

Dividing both sides of the above equation by the aggregate capital stock K_{t-1}, we obtain from the above

$$\frac{I_t}{K_{t-1}} = \phi \frac{\Delta M_t}{K_{t-1}} + \frac{1}{AU^*} \frac{EY_t}{K_{t-1}} \varsigma_y - (1-d)\varsigma_k \tag{11}$$

where Y_t is the aggregate demand and the parameters ς_y and ς_k can be expressed as the proportions of demand and capital stock from $n - n_1$ firms over Y_t and K_{t-1} respectively. In particular,

$$\varsigma_y = \frac{\sum_{i=n_1+1}^{n-n_1} EY_{i,t}}{EY_t}, \quad \varsigma_k = \frac{\sum_{i=n_1+1}^{n-n_1} K_{i,t-1}}{K_{t-1}}$$

We assume both of them, along with ϕ to be time invariant.

In order for our analysis to be tractable, we shall now assume two linear proportions: one is between the aggregate money supply and the aggregate capital stock $K_{t-1} = \upsilon M_{t-1}$; the other is between the aggregate expected demand and the aggregate demand in the past $EY_t = eY_{t-1}$, where υ and e are both parameters. Since we are working with aggregate variables, the rationality of these two linear proportions are considered more from the statistical view point.[12] In the next section, we will provide a statistical analysis of our proposed investment function.

Given these two linear proportions, we can now re-write our aggregate investment function (11) as

$$I_t/K_{t-1} = \xi_i + \xi_u U_{t-1} + \xi_m m_t \tag{12}$$

where $m_t = \Delta M_t / M_{t-1}$ is the growth rate of money supply; $U_{t-1} = Y_{t-1}/AK_{t-1}$ is the aggregate capacity utilization; the parameters ξ_i, ξ_u and ξ_m are given by

$$\xi_i = -(1-d)\varsigma_k, \quad \xi_u = e\varsigma_y / U^*, \quad \xi_m = \phi/\upsilon.$$

[12]although the later proportion may also imply some expectation behavior.

4 The Structure Form of the Model

Given the discussion on the investment in the last section, we shall now in this section construct a simple macro dynamic model that will provide a basis to evaluate the deflationary expansion in the recent business cycle in the Chinese economy. The model we present here is not a standard equilibrium model but a disequilibrium model with many Keynesian features. It permits the disequilibrium both in labor and product market in response to which the price and wage are adjusted in a staggered way. Due to the transition and developing nature of the Chinese economy, such a Keynesian property is perhaps more important to evaluate business cycle phenomena as they occur in China.

4.1 The Output and Investment

Consider a closed economy in which output is driven by investment. Time is discrete and is indexed by t, $t = 1, 2, ...$ To simplify our analysis, we may assume that the relation between output and investment is linear so that we may write

$$Y_t = \theta I_t, \quad \theta > 1. \tag{13}$$

Above, Y_t and I_t refer to output and investment in period t.

Following the discussion in the last section, we shall write the investment function as

$$I_{t+1}/K_t = \xi_i + \xi_u U_t + \xi_m(m_t - p_t) + \mu_{t+1}, \quad \xi_u, \xi_m > 0 \tag{14}$$

where K_t is the capital stock; U_t is the capacity utilization; m_t is the growth rate of the money supply; p_t is the inflation rate and μ_t can be regarded as a shock. Note that here $(m_t - p_t)$ can be regarded approximately as the growth rate of the real money supply. Compared to (12) in the last section, we here adopt the real money growth rather than nominal money growth as an impact on investment. Meanwhile we also introduce the shock μ_t into the investment function. Rather than assuming μ_t to be purely stochastic, we shall assume that μ_t follow:

$$\mu_t = \rho\mu_{t-1} + \varepsilon_t, \quad \rho \in (0, 1) \tag{15}$$

where ε_t is an *i.i.d.* innovation.

The capacity utilization U can be written as

$$U_t = \frac{Y_t}{AK_{t-1}} \tag{16}$$

This indicates that the capital stock in period $t-1$ is now measured at the end of period $t-1$ (or at the beginning of period t) so that it provides the production capacity for period t.[13]

4.2 Price and Wage Dynamics

Next, we shall discuss how price is determined. We shall not assume that the price will be determined at the level that can clear the market at every period. This is particularly true to China since China is still a transitional and developing economy. Following the widely discussed dual Philip curves of price and wage (see Flaschel, Gong and Semmler 2001 and Fair 2000), we may consider the following price and wage dynamics:

$$w_t = \alpha_w + \alpha_p p_t + \alpha_n(N_t - \bar{N}) + \alpha_x x_t, \quad \alpha_p, \alpha_n, \alpha_x > 0 \tag{17}$$

$$p_t = \beta_p + \beta_w w_t + \beta_u(U_t - \bar{U}) - \beta_x x_t, \quad \beta_w, \beta_u, \beta_x > 0 \tag{18}$$

where w_t is the growth rate of nominal wage rate; N_t is the employment rate; x_t is the growth rate of labor productivity; and $\bar{N}$ and $\bar{U}$ can be regarded as the normal levels of N_t and U_t, beyond which inflation in wage and price will be accelerated. Apparently, our expression of price and wage dynamics is based on the fairly symmetric assumptions on the causes of price and wage inflation. Both of them are driven, on the one hand, by a demand pressure component given by $U_t - \bar{U}$ and $N_t - \bar{N}$, and on the other hand, they are driven by a cost push term measured by p_t, w_t and x_t in the right side of (17) and (18).

With regard to the employment rate N_t, we could write it as

$$N_t = \frac{n(Y_t, ...)}{L_t^s} \tag{19}$$

where L_t^s is the labor supply and $n(\cdot)$ is the demand for labor, which is a function of output Y_t among others. Due to the current dual structure of the Chinese economy, we would expect that L_t^s could be enormous compared to the demand for labor. This will effect the wage equation. The detail will be provided when we turn to the empirical estimation of our dynamic model.

4.3 The Monetary Policy

We know that the government in China has set up a yearly target of money growth, which can be regarded as a major macroeconomic policy for demand

[13] We can also allow the capacity utilization U_t to be defined as in (2). This will not change the basic property of our model, but increase the nonlinearity of the intensive form of our model, which we shall discuss later.

management and growth promotion. Once the target has been set up, the monetary authority employs the credit plan as its principle instrument to implement the target. Although in most cases the credit plan is only indicative, due to state ownership of banks in China, the credit supply from the state banks may not deviate very much from the credit plan.

In the formulation of the money supply function, we shall consider that the government may have a stable (or long term) target of growth rate in the money supply, in addition to the short term target of the inflation rate. We denote this long term target as g. This target is somehow related to the desired economic growth under some acceptable inflation rate (or the desired growth rate in nominal GDP) that the government want to achieve. Given such targets, the yearly money supply will be adjusted according to the actual economic performance:

$$m_t - m_{t-1} = \pi_p(\bar{p} - p_{t-1}) + \pi_m(g - m_{t-1}) \quad \pi_p, \pi_m > 0 \tag{20}$$

where $\bar{p}$ can be regarded as the short term inflation target, which empirically can be computed as a sample mean of p_t. This formulation indicates that the change in money supply will first respond to whether inflation in the previous year is below or above the target inflation rate $\bar{p}$. Second, the change in the money supply also responds to whether the actual money supply in the last year is below or above the long term target. If it is below the long term target, the growth rate of money supply in this year will increase.

Apparently, this formulation of money supply rule reflects the strong attention of the government to use the money supply (or cheap and easy credit) to promote economic growth.

4.4 Model Estimation

The model we construct here involves four key behavior functions (14), (17), (18) and (20). To verify their relevance to China, we provide a simple regression for these four behavior functions by employing annual data from China Statistical Yearbook.[14] We should mention that in China, this annual data is the only data source before 1998. The estimation here is rather unsophisticated due to the lack of data sources with more frequency. Table 2 records the estimated parameters while Figure 2 shows the match of the estimation with the observation.

Table 2: Estimates of Parameters
(the number in parenthesis are the standard errors)

[14]except the capacity utilization U_t, which is computed by Gong and Yang (2002).

set 1	investment function	$\xi_i = -0.1571$ (0.1225) $\xi_u = 0.4010$ (0.1739) $\xi_m = 0.1087$ (0.0367) $\rho = 0.8547$ (0.0776) $DW = 1.9102$
set 2	wage equation	$\alpha_w = 0.0785$ (0.0156) $\alpha_p = 0.6301$ (0.1690) $\alpha_x = 0.3141$ (0.1274) $DW = 1.6453$
set 3	price equation	$\tilde{\beta}_p = -0.4640$ (0.1276) $\beta_w = 0.6732$ (0.1462) $\beta_u = 0.5895$ (0.1702) $\beta_x = 0.1446$ (0.1211) $DW = 1.6919$
set 4	money supply function	$\kappa_0 = 0.1058$ (0.0529) $\kappa_1 = -0.3589$ (0.2611) $\kappa_2 = 0.5674$ (0.2357) $DW = 1.3917$
set 5	other parameters	$\theta = 3.2069$ (0.4019) $A = 0.4760$ (0.0552) $\bar{x} = 0.0536$ (0.0961) $\bar{p} = 0.0600$ (0.0707) $\bar{U} = 0.7500$ (0.0577)

We first discuss the parameters in set 5, named "other parameters." They are estimated with the method of moments by matching the first moments of the corresponding data. Note that here, $\bar{x}$, $\bar{p}$ and $\bar{U}$ are respectively the sample means of x_t, p_t and U_t. The data for estimating θ and A are implied by (13) and (16).

The estimation equations for the four behavior functions take the form

$$I_t/K_{t-1} = \xi_r + \xi_u U_{t-1} + \xi_m(m_{t-1} - p_{t-1}) + \mu_t, \quad \mu_t = \rho\mu_{t-1} + \varepsilon_t \tag{21}$$

$$w_t = \alpha_w + \alpha_p p_t + \alpha_x x_t + \epsilon_t \tag{22}$$

$$p_t = \tilde{\beta}_p + \beta_w w_t + \beta_u U_t - \beta_x x_t + \zeta_t \tag{23}$$

$$m_t = \kappa_0 + \kappa_1 p_{t-1} + \kappa_2 m_{t-1} + \eta_t \tag{24}$$

where ε_t, ϵ_t, ζ_t and η_t are all assumed to *i.i.d.* innovations. We apply the Cochrane-Orcutt procedure to estimate the investment function (21) while the OLS method is directly applied to (22), (23) and (24).

We should note several points here. First, most estimates directly responds to the structure parameters as discussed in the structure form of the

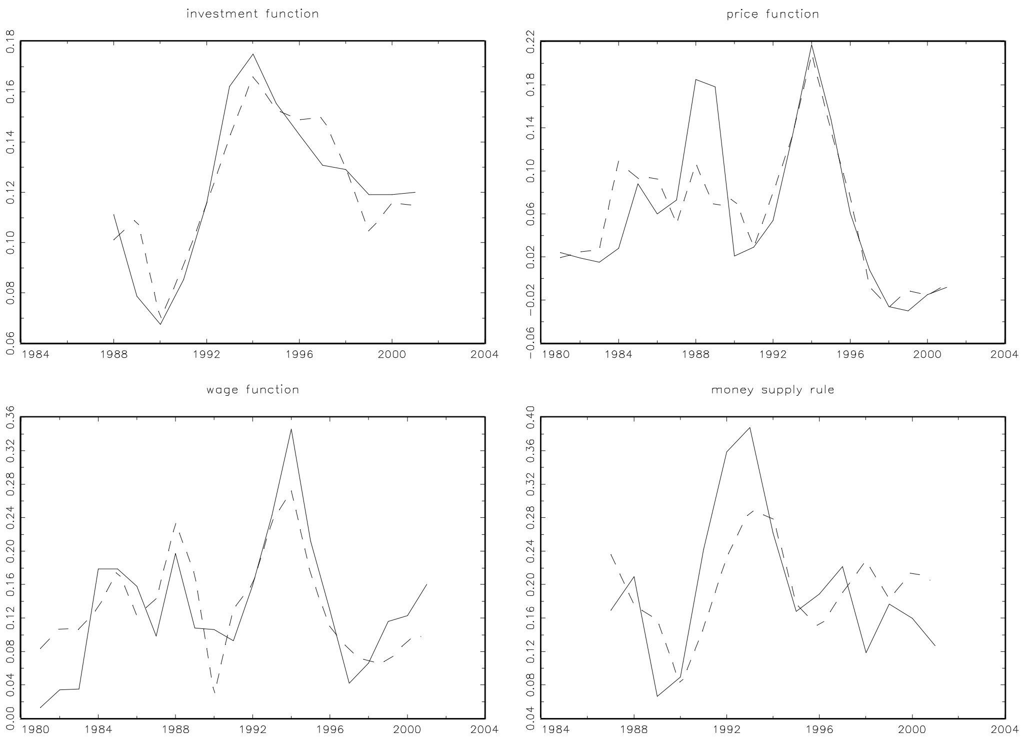

Figure 2: Matching the Observation: the solid lines for sample data, the dashed lines for simulated data

model except here $\tilde{\beta}_p$ here in set 3 and the parameters in set 4. However, from these estimates, we can compute the related structure parameters from the following restrictions:

$$\tilde{\beta}_p = \beta_p - \beta_u \bar{U}, \quad \kappa_0 = \pi_p \bar{p} + \pi_m g, \quad \kappa_1 = -\pi_p, \quad \kappa_2 = 1 - \pi_m$$

Given these restrictions and the estimates of $\bar{U}$ and $\bar{p}$ as in set 5, we can compute that

$$\beta_p = -0.0218, \quad \pi_p = 0.3589, \quad \pi_m = 0.4326, \quad g = 0.1947$$

Note here that the computed g is close to the sample mean of the growth rate of money supply (M1) which is 0.2006.

Second, we have dropped the employment rate $N_t - \bar{N}$ as the explanatory variables in the equations of wage (17). The estimate α_n with respect to $N_t - \bar{N}$ is statistically insignificant. The estimate is -0.0946 while the standard error is 2.3076. As we have discussed in section 2, the labor supply in China as in many developing countries seems to be unlimited due to the enormous labor surplus from rural areas of China. This indicates that we could assume $L_t^s = +\infty$. Given this, we obtain $N = 0$ and $\bar{N} = 0$.

5 The Analysis

In this section, we shall provide a dynamic analysis of the model that we have constructed in the previous section. Our first task is to transform the structure form of the model into an intensive form, which can be expressed as a standard dynamic system in discrete time.

5.1 The Intensive Form of the Model

The following is the proposition regarding our transformation.

Proposition 1 *Let us define $i_t \equiv I_t/K_{t-1}$, and assume that x_t be fixed at $\bar{x}$ while $L^s = +\infty$. The structure form of the model (13) - (20) when we ignore ε_t in (15) can be transformed into a standard three dimensional system, which is composed of*

$$i_t = \xi_0 + \xi_1 i_{t-1} + \xi_m m_{t-1} + \rho \mu_{t-1} \tag{25}$$

$$m_t = \pi_0 - \pi_p \alpha_1 i_{t-1} + (1 - \pi_m) m_{t-1} \tag{26}$$

$$\mu_t = \rho \mu_{t-1} \tag{27}$$

where

$$\begin{aligned}\xi_0 &= \xi_i - \xi_m\alpha_0, \;\; \xi_1 = \xi_u(\theta/A) - \xi_m\alpha_1, \quad \pi_0 = \pi_p\bar{p} + \pi_m g - \pi_p\alpha_0 \\ \alpha_0 &= \frac{\beta_p + \beta_w\alpha_w + \beta_w\alpha_x\bar{x} - \beta_u\bar{U} - \beta_x\bar{x}}{1-\beta_w\alpha_p}, \;\; \alpha_1 = \frac{\beta_u\theta}{(1-\beta_w\alpha_p)A}\end{aligned}$$

The proposition is proved in the appendix. For our non-stochastic dynamic analysis, μ_t can be regarded as an investment shock to the economy if the initial condition μ_0 is not zero. Since we do not have enough information to specify the dynamics of x_t, we have set it to be constant. The assumption $L^s = +\infty$ captures the seemingly unlimited supply of labor reserved in the rural areas of China.

5.2 The Steady State and Stability

The steady state of our dynamic system is well established in the following proposition.

Proposition 2 *The system composed of (25) - (26) has a unique equilibria* $(\bar{i}, \bar{m}, \bar{\mu})$ *at which*

$$\bar{m} = g \tag{28}$$

$$\bar{i} = \frac{1}{1-\xi_1}(\xi_0 + \xi_m g) \tag{29}$$

$$\bar{\mu} = 0 \tag{30}$$

The proof of this proposition is trivial by setting $i_t = i_{t-1} = \bar{i}$, $m_t = m_{t-1} = \bar{m}$ and $\mu_t = \mu_{t-1} = \bar{\mu}$ in (25) - (26).

It should be noted that although the system is three-dimensional, μ is autonomously determined via (27). Therefore, we shall first, for our stability analysis, focus on the system composed of (25) and (26) only. This indicates that we are considering an economy in which the initial condition of μ, denoted as μ_0, is equal to zero. The following is the proposition regarding the stabilities of our dynamic system.

Proposition 3 *Let J be the Jacobian matrix evaluated at the steady state of the system composed of (25) and (26) with $\mu_0 = 0$ and $\lambda_{1,2}$ are the two eigenvalues of J. Suppose that $1 - \beta_w\alpha_p > 0$ and $\xi_1 - \pi_m < 1$. Then there exists a π_p denoted as π_p^* such that in the neighborhood of π_p^*,*

1. *$\lambda_{1,2}$ are complex conjugate;*

2. *the modulus of the complex conjugate denoted as* $|\lambda_{1,2}|$ *can be either below or above 1 depending on the castellation of the structure parameters. In particular,*

   (a) $|\lambda_{1,2}| < 1$ *when* $\pi_p < \pi_p^*$;

   (b) $|\lambda_{1,2}| = 1$ *when* $\pi_p = \pi_p^*$;

   (c) $|\lambda_{1,2}| > 1$ *when* $\pi_p > \pi_p^*$;

3. $\left.\frac{d|\lambda_{1,2}(\pi_p)|}{d\pi_p}\right|_{\pi_p=\pi_p^*} \neq 0.$

The proof of this proposition is provided in the appendix. We should note that the assumption that $1 - \beta_w \alpha_p > 0$ is well satisfied given the estimates recorded in Table 1. However, $\xi_1 - \pi_m < 1$ is not satisfied. According to our estimates, we compute ξ_1 as 1.9517 which is larger than $1 + \pi_m$. Yet, by a small change in some parameter, this assumption could be satisfied. For example, if we adjust β_u to 0.3207, which is 80% of our estimate, ξ_1 becomes 1.4114 and therefore, the assumption is satisfied. Figure 3 provides a simulation with β_u adjusted to 0.3207 while all the other parameters are kept as the same as in Table 2.

With this proposition, one finds that the equilibrium $(\bar{i}, \bar{m})$ may exhibit cyclical behavior. It can either be attracting or repelling depending on the castellation of the structure parameters. For instance, it may depend on the magnitude of π_p (given other structure parameters). In particular, the system undergoes a Hopf-bifurcation at $\pi_p = \pi_p^*$, and therefore it permits the limit cycles.[15] In the case of Figure 3, the cycles are explosive and therefore the equilibrium $(\bar{i}, \bar{m})$ is repelling. This indicates that π_p as we have estimated is larger than the bifurcation π_p^*. In the next subsection, we will explore the case when π_p is less than π_p^*.

5.3 Numerics and the Deflation Cycle in China

Given the analytical result as expressed in the last subsection and the estimated parameters as reported in Table 2, we shall conduct some numerical simulations based on which one may explain the deflationary problem that has occurred recently in the Chinese economy. In this exercise, the only further adjustments on the structural parameters are β_p and π_p, which we set to -0.065 and 0.2405 respectively. The adjustment on β_p allows us to obtain

[15] For the existence theorem of Hopf-bifurcation in two dimensional discrete time dynamic system, see Guckenheimer and Holmes (1986, p. 162).

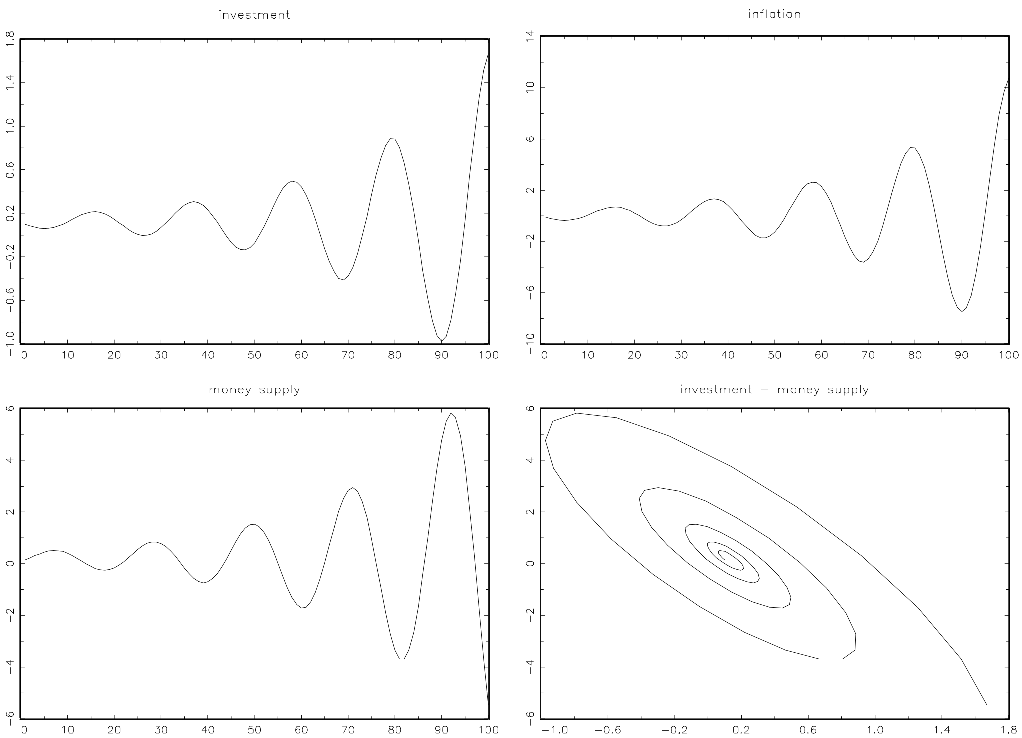

Figure 3: Model Simulation: the Unstable Case

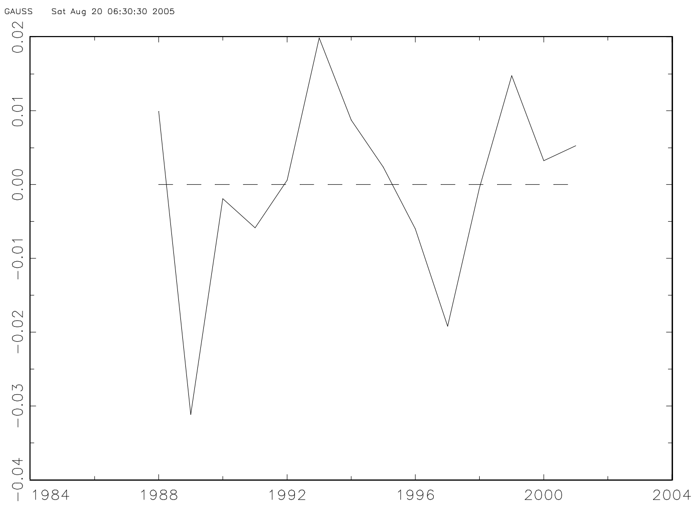

Figure 4: The Residue from the Estimation of Investment Function

a more reasonable steady state in the rate inflation rate. Meanwhile, the adjustment on π_p will make the modulus of the complex conjugate less than 1 (or make π_p less than the bifurcation π_p^*). Given the standard deviations reported in Table 2, we find that such adjustments (including β_u adjusted to 0.3207) are all within the interval of statistical significance. Note that the equilibrium here is attracting since we have adjusted π_p below the bifurcation π_p^* and therefore the system is inherently asymptotically stable. However, even in this case, deflation could still occur when there is an overshooting in investment.

Such overshooting may have been stirred up in 1992. At that time, the economy in China had just been in the recovery from the shadow of Tiananmen Square Incident (see Figure 1 for the related statistics). Deng's speaking-tour in the South of China in 1992 re-established China's development strategy toward a more open and market oriented economy. It thus brought an overshooting in investment in the following year. To verify such overshooting, we may look at the residue from the estimation of our investment function (21). As one can find in Figure 4, there is a sharp increase in the residue (the observed minus predicted) in 1993. This indicates that the overshooting in investment did occur in 1993.

To replicate the economic impact of such overshooting, we may consider the initial condition in our simulation as follows. We consider the initial investment i_0 to be composed of two parts: one is the shock in investment represented by μ_0, another is the investment following its regular path as if there is no shock. We may consider the second part of i_0 to be slightly below the steady state of i since the economy had just been in recovery. Here we assume it was 98% of $\bar{i}$. For μ_0, we consider three numbers: one is 0.0006, another is 0.0003 and the other is zero, indicating no shock. Since the second part of i_0 is below the steady state of i, we shall set the initial condition of money supply m, for all three cases, to be above its steady state $\bar{m}$, indicating the government still wanted to pull the economy from the recession following its regular money supply rule (20). Here we assume m_0 to be 104.5% of $\bar{m}$. Figure 5 provides the simulation for such initial conditions. In particular, given the two shocks represented by the two positive μ_0's, we obtain two impulse response curves: the solid line represents the trajectory generated from the larger shock with $\mu_0 = 0.0006$; while the dashed line is from the small shock with $\mu_0 = 0.0003$. The dotted line is for the case of no shock.

Apparently, without the investment shock, the economy could continuously be in a slump (or below its steady state value) in the next few periods though it was recovered slowly. This is represented by the dotted line with $\mu_0 = 0$. The shock in investment represented by the positive μ_0's generates an investment boom over the subsequent periods. Such an investment boom represented by a strong sequential increase in investment (see Panel a in the figure) not only indicates a strong sequential increase in growth rate of GDP, but also bring a sequential increase in capacity utilization (see Panel c in the figure). The sequential increase in capacity utilization will accelerated the inflation over the subsequent periods (see Panel b in the figure). Once the inflation began to accelerate, the government exercised a contraction policy by reducing the money supply. We thus can find a sequential decrease in the money supply (see Panel d in the figure), which at its lowest point was only about 10%. Such contraction in money supply finally slowed down the investment (see Panel a for the sequential decrease in investment after reaching the peak at about 15%). Yet, the economy had already established a huge capacity from the previous investment boom era. Consequently, when investment (and thus demand) was slowed down, the economy was experiencing serious over capacity (see Panel c for the sequential decrease in capacity utilization after reaching the top at about 100%) and subsequently, price was going down too (see Panel b). We should note that such a variation in simulated series is consistent with the time series variation as we have observed in Figure 1 and 2.

It is interesting to note that if the shock was not large enough, for instance, $\mu_0 = 0.0003$, or if there was no shock, the system does not generate

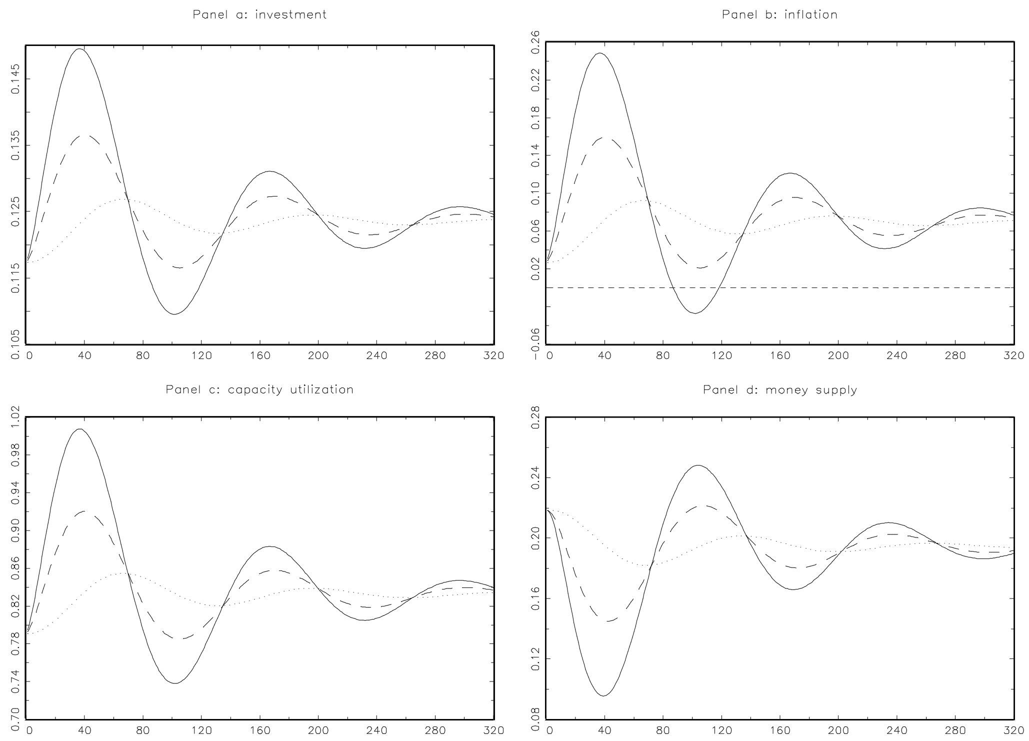

Figure 5: The Impulse Response Curves to Shocks: the solid line for larger shock, the dashed line for small shock and the dotted line for non-shock.

enough volatility and thus deflation may not occur (see the dashed and dotted line in Panel b). It is in this sense that the overshooting ignited in 1993 serves as a fundamental reason for the deflation problem as started in 1997.

6 Discussion

This paper discusses the deflationary expansion in the recent business cycle of the Chinese economy. We have studied this business cycles phenomenon within a model of discrete time dynamics and have found that deflationary expansion could be possible if driven by an overshooting in investment and if the steady state of the economy is at a high rate of growth. An overshooting in investment first causes excess demand and thus accelerates inflation. When the government conducts an anti-inflation policy via demand management, it then causes deflation due to the huge excess capacity accumulated in the preceding over-investment. These dynamics can be simulated in our model and is consistent with the empirical data we have observed. The high steady state of growth can be explained by the institutional environment of China. In particular, the high growth of the economy is driven by the high growth in investment, which creates not only fast accumulation of capacity, but also aggregate demand. The fast accumulation of capacity requires the absorption of more people to work in urban areas. It is the dual structural of the economy (implying a huge unused economic resource: labor) that makes the absorption possible. The easy and cheap credit via the state banking system provides sufficient financial resource required for high rate of investment.

7 Appendix

7.1 The Proof of Proposition 1

By definition on i_t, equation (14) can be written as

$$i_t = \xi_i + \xi_u U_{t-1} + \xi_m m_{t-1} - \xi_m p_{t-1} + \mu_t \tag{31}$$

We now consider the capacity utilization U_t and the inflation rate p_t. From (16) when Y_t is expressed by (13), we find that U_t is a linear function of i_t:

$$U_t = (\theta/A) i_t \tag{32}$$

Equation (18) and (17) indicates that

$$p_t = \beta_p + \beta_w \left(\alpha_w + \alpha_p p_t + \alpha_x \bar{x}\right) + \beta_u (U_t - \bar{U}) - \beta_x \bar{x}$$

Expressing U_t in terms of (32), we can re-write, after re-organizing, the above equation as

$$p_t = \alpha_0 + \alpha_1 i_t \tag{33}$$

where α_0 and α_1 are given in proposition 1. Substituting (15), (33) and (32) into (31) while ignoring ε_t, we obtain (25) as in proposition 1. At the same time, substituting (33) into (20), we obtain (26) as in the proposition. Equation (27) in proposition 1 is trivial when we ignore ε_t.

7.2 The Proof of Proposition 3

At the equilibrium $(\bar{i}, \bar{m})$, the Jacobian matrix of the system (25) and (26) can be written as

$$J = \begin{bmatrix} \xi_1 & \xi_m \\ -\pi_p \alpha_1 & 1 - \pi_m \end{bmatrix}$$

Thus, the characteristic equation takes the form

$$\lambda^2 - a_1 \lambda + a_2 = 0$$

where

$$a_1 = (\xi_1 + 1 - \pi_m), \quad a_2 = (1 - \pi_m)\xi_1 + \xi_m \pi_p \alpha_1$$

We shall first note that both π_p and π_m have no impact on either ξ_1 or α_1. On the other hand, the assumption $1 - \beta_w \alpha_p > 0$ indicates that $\alpha_1 > 0$. Let us now derive the bifurcation π_p^* on the assumption that the eigenvalues $\lambda_{1,2}$ are complex conjugate. This can be done by assuming that the modulus $|\lambda_{1,2}|$ (which is a_2) equal 1, that is,

$$(1 - \pi_m)\xi_1 + \xi_m \pi_p \alpha_1 = 1$$

Solving this equation for π_p, we obtain

$$\pi_p^* = \frac{1 - (1 - \pi_m)\xi_1}{\xi_m \alpha_1} \tag{34}$$

Given this π_p^*, we shall now prove that the eigenvalues $\lambda_{1,2}$ are complex conjugate. This requests that $a_1^2 - 4a_2 < 0$, that is,

$$(\xi_1 + 1 - \pi_m)^2 - 4\left[(1 - \pi_m)\xi_1 + \xi_m \pi_p^* \alpha_1\right] < 0 \tag{35}$$

Substituting (34) into (35), the request (35) becomes

$$(\xi_1 + 1 - \pi_m)^2 - 4\left[(1 - \pi_m)\xi_1 + 1 - (1 - \pi_m)\xi_1\right] < 0$$

This inequality hold under the assumption $\xi_1 - \pi_m < 1$. We therefore prove 1 in the proposition.

Next,

$$\frac{d\left|\lambda_{1,2}(\pi_p)\right|}{d\pi_p} = \xi_m \alpha_1 > 0$$

2 and 3 in the proposition are thus proved.

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