



LUND UNIVERSITY
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**Master Program in Economic Growth,
Innovation and Spatial Dynamics**

**The Relationship between Inflation and Economic Growth of China: Empirical
Study from 1978 to 2007**

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Abstract: This thesis is to research the relationship between inflation and economic growth of China from 1978 to 2007. No unambiguous conclusions on this problems have been obtained from previous literatures. This thesis will employ co-integration and error correction models accompanying with correlation matrix and the Granger Causality Test to examine the inflation-economic growth relationship. The data is annual time series from 1978 to 2007 of China. The results show that in the long run inflation positively relate to economic growth in bi-direction. China would pay attention to price level when develops economy. Besides, high speed increase of investment would cause inflation in the short run.

Key words: Inflation, Economic Growth, Co-integration and Error Correction Models, China

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1 Introduction

What is your reaction when you find you have to pay twice than before to buy a kilo of pork? You may think it may be temporary price adjustment by the manufacturer. But if the price increase happens in almost all commodities and last for a quite while, you could have reasons to believe that inflation may have appeared. Of course, inflation as one of the indicators of macro-economy has a more precise definition than mentioned above. But inflation has a very close connection to people's common life by observing the price level. In the late of 2007, Chinese citizens have experienced a increase in price level in their daily life. The increase is from pork, noodles and other food and then spreads to other commodities. The statistics show that CPI of China has increased by 4.8% compared to that of last year. And the trend of increasing in CPI has lasted to 2008. Dose that mean high speed economic growth also happen during the period? Because with the experience of development in the last 30 years, the two macro-economic phenomena are often accompanied in China. But is it true? From late of 2007 till early of 2008, as the deepening of subprime lending crisis of the United States, world economy is under a high pressure to decline. A new round financial crisis has come. As the closer connection with international markets, China would also suffered from the crisis. Then how to stabilize price level when keeping high speed of economic growth is a critical problem for policy-makers of China at present. Knowing the relationship between inflation and economic growth would provide some useful implications.

Previous studies on inflation - economic growth relationship have revealed the complexity of the issue. They show that there might be no-relationship, negative relationship and positive relationship between inflation and economic growth according to different conditions. Most empirical studies support negative inflation - economic growth relationship especially when inflation is above the threshold level. But for the low or moderate inflation, there is distinctive disagreement. Some studies

show zero-relationship, while others shows a statistically positive inflation - economic growth relationship. From the aspect of causal direction, two opposite points of view exist. One believes inflation could be conducive to growth¹. The other argues that growth could cause inflation². Furthermore, Faria and Carneiro (2001) believes in that inflation - economic growth is just a short-run phenomenon. However, Mallik and Chowdhury (2001) evidence that inflation positively relates to growth in the long run.

In this thesis, I will research the inflation-economic growth relationship of China from sampling year of 1978-2007. In methodology part correlation matrix and Granger Causality Test will be adopted to detect the relationship and the causal direction between the two variables. Most of important, co-integration and error correction models will be employed to explore whether inflation and economic growth have the long-run equilibrium relationship. Besides the main task of detecting inflation-economic growth relationship, capital accumulation will also be included to find whether it will relate to inflation.

The estimation will be conducted by Eviews 6.0. The data are annual time series from the World Bank, International Monetary Fund and National Bureau of Statistics of China.

This thesis focuses on detecting the nature of inflation-economic growth relationship. But many empirical studies have shown that inflation and economic growth have non-linear relationship. Then further studies on detecting the structural break point of inflation of China is meaningful.

Section 1 is introduction; section 2 reviews both previous theoretical literatures and previous empirical studies; section 3 summaries economic development, inflation and capital accumulation in the context of China; data description is given in section 4;

¹ Fischer (1993)

² Gokal and Hanif (2004); Wang Zhiyong (2008)

section 5 is methodology and estimation; and section 6 concludes this thesis.

2 Literature Review

2.1 Theory Review

Inflation is not a new topic in economic theories. The phenomenon of inflation and its effect on real economic variables has been discussed ever since the appearance of classical economic theory and been furthered later on as the development of modern economic theories. In this section, there will be a review of different economic theories, and the focus is on the explanations of inflation and its effect on economic growth under the framework of these theories rather than details of theories themselves.

Keynesian Theory

In 1936, John Maynard Keynes wrote the book “The General Theory of Employment, Interest and Money” which establishes the foundation of Keynesianism and also the modern macroeconomics. Keynesianism argues that in the scale of macro-economy, at given level resources, full production and full employment are hard to be achieved just resting upon market adjustment, which is contrary to the opinion of Say’s Law. Keynesianism believes in that interventions in economy by governments through expansionary economic policies will boost investment and promote demand to reach full production. The promoted demand before full production is termed as effective demand which maximize the utilization of limited resources, in contrary, the demand beyond full production is defined as excess demand. In the framework of Keynesianism, the AD (Aggregate Demand) and AS(Aggregate Supply) curves are adopted to show the relationship between output, employment and inflation. (See Figure 1)

When current resources are not fully utilized, promoting effective demand through interventions by governments will improve output and employment without generating inflation until output reaches its full production level: Y_2 (which is determined by the long-run AS curve). Figure 1 shows that the AD curve is at the position AD_1 under which full output and employment are not achieved. Promoting effective demand will shift the curve move from position AD_1 outwards to position AD_2 under which output arrives at its full production level but price will not increase (still staying at P_1). But if demand rises further, the curve will keep on moving from position AD_2 outwards till position AD_3 . In this case, output will not increase as full output has been reached at Y_2 in position AD_2 , but the price will inevitably increase to P_2 (the long-run steady state of output) caused by excess demand. Then the inflation phenomenon has appeared. This type inflation are caused by excess demand, so it is defined as demand-pull inflation. However, as shown in Figure1, the demand-pull inflation will not have influence on the output in the long run.

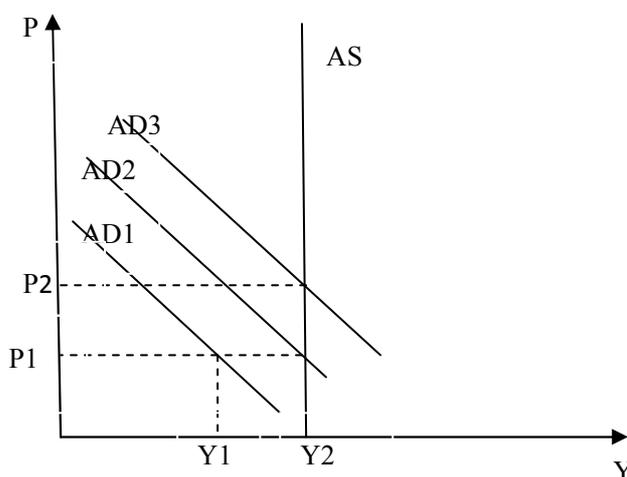


Figure 1 AD-AS Curve under the Framework of Keynesianism

P: nominal Price

Y: output

Monetarism Theory

“Stagflation” (a phenomenon that incorporate high inflation and low growth or high unemployment) that dominated in almost all developed countries in the middle of 1970’s. However, Keynesianism can neither explain this phenomenon properly nor provide any resolutions under the framework of Keynesian theory. At the other hand, another school of economic theory – monetarism – has been popular, which argues that money supply is the only factor that determines price levels in an economy and the only intervention that a government can do is to manage the growth rate of money supply to harmonize it with the growth rate of output in the long run. Equation (1) below shows the transformation of Quantity Theory of Money which depicts a unambiguously negative relationship between inflation and economic growth.

$$\pi = \frac{\Delta M}{M} - \frac{\Delta Y}{Y} \quad (1)^3$$

π inflation

$\frac{\Delta M}{M}$ the growth rate of money supply

$\frac{\Delta Y}{Y}$ the growth rate output

At the same time, Phillips Curve which argues the tradeoff relationship between inflation and unemployment can not give a satisfactory explanation for the combination of high inflation and high unemployment. Phillips Curve is questioned by representative monetarism scholar: Milton Friedman. Monetarism believes that “stagflation” is due to the high interventions for market by governments, which distorts the market mechanism. Under this circumstance, Philips Curve will show a upward sloping curve which positively relates inflation and unemployment. “Stagflation” deteriorates Phillips Curve totally. Monetarism further puts the concept of anticipation into Phillips Curve and divide Phillips Curve into short-run and

³ Mankiw (2002)

long-run ones. In the short run, if anticipated inflation is less than actual inflation, individuals' actual wages will be less than nominal wages. Then increasing firms' profits will boost investment, which finally decrease unemployment. Therefore, Phillips Curve will hold in the short run. But in the long run, anticipated inflation will inevitably be consistent with actual inflation. Individuals' actual wages will be identical to nominal wages. Inflation will have no influence on unemployment, output and other real economic variables. This circumstance is defined as the neutrality or superneutrality of money. According to Gokal and Hanif (2004), "Neutrality holds if the equilibrium values of real variables – including the level of GDP - are independent of the level of the money supply in the long-run. Superneutrality holds when real variables – including the rate of growth of GDP – are independent of the rate of growth in the money supply in the long-run." (Gokal and Hanif, 2004, pp. 9)

Neo-classical Growth Theory

Neo-classical growth theory starts an era that economists try to generate long-run equilibrium models to formulate economic growth and its determinants. Solow and Swan are two pioneers who put forward their growth models respectively under the framework of neo-classical economic theory. The Solow growth model assumes "diminishing returns to labour and capital separately and constant returns to both factors jointly." (Gokal and Hanif, 2004, pp. 10) One of the features of this model is that saving rate, the growth rate of population and technological progress are defined to be exogenous. The capital level will move to and stabilize at the steady state on which output will keep constant at given exogenous variables. Once this balance is broken by change of exogenous variables, new steady state will be achieved. Furthermore, Abramovitz and Solow adopt growth accounting to give a direct expression of composition of economic growth based on the Solow model shown in equation (2) at below.

“

$$\frac{Y^*(t)}{Y(t)} - \frac{L^*(t)}{L(t)} = \alpha_k(t) \left[\frac{K^*(t)}{K(t)} - \frac{L^*(t)}{L(t)} \right] + R(t) \quad (2)$$

$\frac{Y^*(t)}{Y(t)}$ growth rate of output

$\frac{K^*(t)}{K(t)}$ growth rate of capital

$\frac{L^*(t)}{L(t)}$ growth rate of labour

$\alpha_k(t)$ the elasticity of output with respect to capital at time t

$R(t)$ the Solow Residual

”(Romer, 2006, pp. 29)

Equation (2) shows the channels through which variables will affect economic growth. It is obvious that growth under the Solow model will relate to the growth of capital, labour and the Solow Residuals. The Solow Residuals is TFP (Total Factor Productivity) which is regarded as the index of technological progress.

Although growth accounting method tell us the channels through which variables influence on economic growth, there is still lack of direct explanation of the relationship between inflation and economic growth. Mundell (1963) and Tobin (1965) have successfully explained the effect of inflation on economic growth based on neo-classical growth theory. They believe increased nominal interest caused by inflation will make people option to investment instead of consumption. This will result in increasing capital accumulation which will stimulate economic growth. This is the Mundell-Tobin Effect. Mundell (1963) and Tobin (1965) depict a positive relationship between inflation and economic growth.

Sidrauski (1967) collaborates monetary factors with neo-classical growth model with the assumption of neutrality of money. But he tries to testify how the model will react

to the change of growth rate of money supply. In the model of Sidrauski (1967), although he does not give a distinct path how the new steady state is achieved upon the change of growth rate of money supply, conclusion is that inflation will have no relation with output growth rate in the long run. This findings support the superneutrality of money.

Contrary to the conclusion of the Mundell-Tobin Effect, Stockman (1981) develops a long-run equilibrium growth model with assumption of “cash-in-advance constraint”. In the model of Mundell (1963) and Tobin (1965), real money balances and investment are substitution. But in the model of Stockman (1981), the two variables’ relationship is complement. As the return on investment is also gained by individuals in the form of money in future. The inflation will reduce both real money balances and investment. And then inflation will negatively influence on growth.

New Growth Theory

New growth theory is also termed as endogenous growth theory, as it assumes technological progress as endogenous, which is contrary to neo-classical growth theory whose assumption is based on exogenous saving rate, population growth and technological progress. Also, new growth theory assumes that marginal product of capital is constant, but in neo-classical growth theory, the capital is assumed to be diminishing on return.

If discussing new growth model under the framework of monetary economy, then the relationship between inflation and return rate on capital will depend on the relationship between real money balances and investment. As discussed in the part of neo-classical theory and the studies of Mundell (1963), Tobin (1965), Haslag(1997) and Stockman (1981), if real money balances substitute investment, the inflation will decrease the return on real money balances but the return on investment will increase. A positive relationship between inflation and economic growth will show. But if real

money balances complement investment, inflation will have negative effect on growth.

2.2 Empirical Studies Review

Theory review section has shown different arguments about inflation and its effect on economic growth. In fact, in the context of real world, without the assumptions and restrictions of theories, the relationship between inflation and economic growth is more complicated. The results of previous studies has supported the complexity of this issue. And up to now there is still no conclusive argument about the nature of the inflation – economic growth relationship from previous empirical studies.

Previous studies not only try to test the existence of the relationship, but also try to dig this question deeper. The involved studying content includes: what is the causal direction of the relationship; is it a one-way or two-way direction; whether the relationship holds in the long-run or just a short-run phenomenon; is the relationship linear or non-linear; if there are non-linear effects, what is the structural break point of inflation and etc. Different studies have different focus in researching.

When discussing the relationship between two variables, it is important to know through which channels they relate to each other, because it will help to understand further the nature of the relationship. As mentioned in theory section, Abramovitz and Solow has adopted growth accounting to formulate the determinants of economic growth. Fischer (1993) further the study by relying on the growth accounting method with empirical data. He calculates Solow residuals and make regression of economic growth and other elements of economic growth (e.g. growth of capital accumulation, productivity residual and so on) based on inflation respectively. His studying results show that inflation can influence economic growth not only through total factor productivity but also through capital accumulation. Fischer (1993) concludes his

paper that the negative relationship exists between inflation and economic growth, he still points with much caution that there is no direct evidence to support low inflation-high economic growth pattern, i.e. low inflation is not sufficient condition for economic growth. Many empirical studies support this opinion, though that high inflation is bad for growth is not doubtful, few results show a causal phenomenon that lower inflation will lead to higher growth.

Theoretical models have shown that investment (capital accumulation) moves the same direction with economic growth. But there is disagreement on the effect of inflation on investment (capital accumulation). If the inflation-investment relationship is studied under the framework of monetary economy, as mentioned in theory section, it will depend on the relationship between real money balances and investment. One argument is substitution effect of real money balances on investment, such as the studies by Mundell (1963) and Tobin (1965). The contrary argument is complementary effect of real money balances on investment, such as the study by Stockman (1981).

Moreover, Fischer (1993) also believes that inflation will be detrimental to investment. He argues that inflation distorts price mechanism, and then distorted price level will affect the efficiency of resources' allocation. This influence will finally negatively relate to economic growth. Gregorio (1992) also support the view that inflation will affect growth through reducing the efficiency of resources' allocation. He develops a model to elaborate that inflation will change return on money and capital and then alter the choice by firms and consumers, and they may option to economic activities for the sake of adverse-risk. These changes has affected the power of price mechanism and distort the originally effective resources' allocation.

With the development of research in inflation – economic growth relationship, there has been studies pointing out the complexity of the relationship may involve in the non-linear effect. The non-linearity has been the hotspot in the studies of the

relationship between inflation and economic growth ever since 1990's. Fischer (1993) is the first that evidences the non-linearity by adopting spline functions. The spline functions estimates the results by assembling the data of inflation into three ranges according to the level of inflation. Also his study shows that there are more than one break point between inflation and economic growth and the negative coefficients of inflation – economic growth relationship is decreasing quicker when inflation is higher. Buerdekin et al. (2000) further the study of non-linearity in inflation – economic growth relationship. They argue that levels of break points should be different and distinguished in estimation between developed and developing countries. But totally contrary to the results of other studies which focus on studying the threshold of inflation – economic growth relationship, they find a higher threshold with 8% for developed countries and a lower one with 3% for developing countries. Another representative research of the non-linearity in inflation - economic growth relationship is by Khan and Senhadji (2000), they adopt economic estimation tool to detect the threshold of inflation instead of fixing them by assumption like Fischer (1993) and Burdekin et al. (2000). In the study of Khan and Senhadji (2000), they detect the break points of 1-3% for developed countries; 7-11% for developing countries; and evidence again that above the break points, inflation negatively relates with economic growth. Mubarik (2005) follows the study of Khan and Senhadji (2000) and detects a structural break point of inflation of 9% for Pakistan, above the break point there is a negative inflation - economic growth relationship, but no significant relationship below the break point. He also evidences a one-way direction relationship from inflation to growth by Granger Causality method.

Most empirical literatures focusing on studying the threshold of inflation under the framework of inflation - economic growth relationship have detected a higher threshold for developing countries than for developed countries. One of explanation by Khan and Senhadji (2000) is that developing countries employ inflation as a kind of tax because of lacking effective tax system in these countries. Furthermore, Christoffersen and Doyle (1998) argue that the different levels in threshold of

inflation actually reflect a country's structural features, therefore studies on different countries will have different results. But studies have shown that thresholds of inflation will converge to developed countries' level as developing countries progress.

Some recent studies begin to adopt new econometric techniques, like the co-integration and error correction models for dealing with time series data to examine the relationship of the model of bivariate variables. Mallik and Chowdhury (2001) first adopts the two above-mentioned models to exploit the inflation - economic growth relationship. They conclude a long-run positive relationship between inflation and economic growth. Ahmed and Mortaza (2005) further employ the above mentioned estimation models to find both long-run and short-run relationship between inflation and economic growth in Bangladesh and then followed by OLS (Ordinary Least Squares) model to evidence the structural break point of inflation for Bangladesh is 6%. Same with most of the other studies for detecting the threshold level of inflation, Ahmed and Mortaza (2005) show that the inflation - economic growth in Bangladesh is negative when inflation exceeds structural break point, but there is no statistically significant relationship below the break point.

Sidrauski (1967) testifies the superneutrality of money in his model with conclusion that inflation has no relationship with growth in the long run. Some recent empirical studies which evidence the zero inflation - economic growth relationship especially in the long run support Sidrauski (1967)'s argument. Bruno and Easterly (1995) demonstrates a non-relationship between inflation and economic growth when they delete observations of high inflation cases. Because some studies show that the inflation - economic growth relationship are very sensitive to the high inflation cases. However, Faria and Carneiro (2001) instead study Brazil – a country with high inflation history, same result of non-relationship in the long run is concluded though still finding a short-run negative relationship. The two extreme studies give a strong support to the superneutrality of money in the long run and also provide the implication it is worthwhile for further research to test the hypothesis that high

inflation contributes to the inflation - economic growth relationship in the short run. But contrary to the conclusion of Faria and Carneiro (2001), Gregorio (1992) also conducts a study based on 12 Latin American Countries which have high inflation history. His results found a negative relationship between inflation and economic growth in the long run. Gregorio (1996) furthers the study in his work of 1996 and stresses the importance of central bank to control the inflation, and same with the result of his work in 1992, he still concludes a robust negative relationship between inflation and economic growth.

The most distinctive part of the study by Gokal and Hanif (2004) is that they detailedly review the development of inflation - economic growth relationship from theoretical angle. They also summarize that one of the externalities of inflation is inflation uncertainty, which is generated by inflation and will inversely affect growth. Fischer (1993) has also mentioned inflation uncertainty will have same effect with inflation on growth by distorting market mechanism. More and more recent studies focus on the research of inflation uncertainty because understanding it could shed some light on the inflation - economic growth relationship. Previous studies show a consistent positive relationship between inflation and inflation uncertainty. Although Golob (1994) emphasize the downward trend of inflation uncertainty which is neglected by previous studies, the result of his study still support a positive relationship between inflation and inflation uncertainty.

Time series data is often been adopted when analyzing a country's financial related variable, because this kind of data can capture the variability of financial data. Sweidan (2004) adopts annual time series data of Jordan by using of ARCH (Autoregressive Conditional Heteroskedasticity) model to detect the relationship between inflation and inflation uncertainty. His study confirm the positive relationship between inflation and inflation uncertainty in the context of Jordan. But he evidences no significant relationship between inflation uncertainty and economic growth, which is contrary to his assumption.

Though there is a consensus that high inflation is harmful, still high inflation cases in real world exist. The main explanation is that reducing inflation would cause higher costs in economic growth. However the effect of low-moderate inflation on growth is still debated as mentioned by the results in other empirical studies in this section. In the study of Ghosh and Phillips (1998), they explain why different level of price variability will have different influence on the inflation - economic growth relationship. They believe that low inflation is necessary and could weaken the price rigidity and then improve the efficiency of price mechanism, but high inflation will lead inefficient allocation of resources by distorted price variability.

The study of Christoffersen and Doyle (1998) focus on growth pattern of the transition countries (including the Central European Economies and the former Soviet Union) and show the distinct effects of export growth and structural reform on economic growth for transition economies. They detect the structural break point of 13% above which inflation negatively affects economic growth, but when inflation below the threshold, there is no significant inflation - economic growth relationship. China as one of transition economy also bears the features that export growth and structural reform are two of major constitutions of economic growth. Wang Zhiyong (2008) adopts co-integration and error correction models to detect inflation - economic growth relationship of China. He finds that economic growth positively relates to inflation with about three quarters' lag and the causal direction is one-way from growth to inflation. The findings are different to the results of other studies mentioned above most which find the causal direction from inflation to growth. The conclusion from Wang Zhiyong (2008) have strong implications for policymakers of China that it is important to keep a close eye on inflation in the context of high growth in the economy.

One of the problem that disturbs the study of inflation - economic growth relationship is the robustness of estimation results. Many empirical studies show that if concluding

control variables, the result of inflation - economic growth relationship is weak and non-significant. Although there still other studies also find a robust relationship when controlling other variables, cautions should be born in mind when interpreting the estimation results.

Previous studies have shown a diversified arguments about inflation - economic growth relationship. Although negative effect of inflation on growth above threshold of inflation prevails in empirical literatures, positive relationship even non-relationship when inflation is moderate or low still exist. The diversity in results show the complexity of inflation - economic growth relationship. I summarize part of empirical studies in Table 1. It could be noticed that country characteristics, time period of research, form of data, analysis and estimation method and etc. will all have influence on the final results.

Table 1 Empirical Studies on Inflation - economic growth Relationship

| Author | Studyin g Country | Data | Estimatio n Method | Results |
|--------------------|---------------------------------------|---------------------------------------|---|--|
| Gregorio (1992) | 12 Latin America n countries | panel data: 1950-1985 | GLS (Generaliz ed Least Squares) | Negatively long-run relationship between inflation and economic growth |
| Fischer (1993) | multi-co untries | cross-secti onal and panel data | OLS (Ordinary Least Squares); GLS (Generaliz ed Least Squares) | Negative relationship between inflation and economic growth; causal direction from inflation to economic growth |

| | | | | |
|---------------------------------|---|-------------------------------------|---|--|
| Christoffersen and Doyle (1998) | 16 transition countries | unbalanced panel data: 1990-1997 | regression model | structural break point at 13% above which negative inflation - economic growth relationship; below which no significant relationship |
| Ghosh and Phillips (1998) | 145 countries | panel data: 1960-1996 | regression model | positive inflation - economic growth relationship when inflation is low; but the relationship turns to be negative for high inflation cases |
| Burdekin et al. (2000) | both developed and developing countries | panel data: 1967-1992 | GLS (Generalized Least Squares) | Structural break point: 8% for developed countries and 3% for developing countries; negative relationship between inflation and economic growth above break point of inflation |
| Khan and Senhadji (2000) | 140 developed and developing countries | panel data: 1960-1998 | GLS (Generalized Least Squares); 2SLS (Two-stage Least Squares) | thresholds break at 1-3% for developed countries and 7-11% for developing countries above which inflation negatively relates with economic growth. |
| Faria and Carneiro (2001) | Brazil | monthly time series data: 1980-2005 | VAR (Vector Autoregressive) model | No inflation - economic growth relationship in the long run but detecting negative relationship in short run |
| Mallik and Chowdhury (2001) | Bangladesh, India, Pakistan, Sri Lanka | Annual time series data: 1970-2000 | co-integration and error correction model | long-run positive inflation - economic growth relationship |

| | | | | |
|--------------------------|------------|--|---|--|
| Gokal and Hanif (2004) | Fiji | time series data: 1970-2003 | correlation analysis; Granger Causality | assuming break point at 8% above which the inflation - economic growth relationship is negative but not robust; growth Granger causes inflation |
| Sweidan (2004) | Jordan | Annual time series data: 1970-2003 | ARCH (Autoregressive Conditional Heteroskedasticity) and OLS (Ordinary Least Squares) | Non-linearity breaks at inflation of 2%, above which negative inflation - economic growth relationship, below the break point, the relationship is positive; also detecting a positive relationship between inflation and inflation uncertainty, but no effect of inflation uncertainty on economic growth |
| Ahmed and Mortaza (2005) | Bangladesh | Annual time series data: 1980-2005 | co-integration and error correction model; OLS (Ordinary Least Squares) | both long-run and short-run inflation - economic growth relationship with break point at 6% above which negative relationship below which no significant relationship |
| Mubarik (2005) | Pakistan | Annual time series data: 1973-2000 | OLS (Ordinary Least Squares) and 2SLS (Two-stage Least Squares) | structural break point of inflation is 9% for Pakistan, above the break point there is negative inflation - economic growth relationship, but below the break point there is no significant relationship |
| Wang, Zhiyong, (2008) | China | Annual and quarter time series data: 1981-2004 | co-integration and error correction models | economic growth positively relates to inflation with about three quarters' lag; causal direction is one-way from growth to inflation |

Source: From the respective studies mentioned in Table 1

3 Economic Growth, Inflation and Capital Accumulation in China

3.1 Economic Growth

It is well known that China has achieved impressive economic growth from 1979 when economic reforms and opening policies have been conducted in this country. Actually, ever since the foundation of People's Republic of China in 1949, economic development has been one of the most important goal for China. From the data of GDP of China from 1961, it can be found that even before 1978, China's real GDP growth and real GDP per capita growth have averaged at 4.84%⁴ (1961-1977) and 2.68%⁵ (1961-1977) respectively during which China has encountered one of its most difficult era after the foundation of the new country including sharp negative impact on economic growth by the Three-Year Natural Disasters and Culture Revolution and other factors. Since 1978, China's economy has been growing steadily although growth rate fluctuates among the years. From 1978 to 2007, the growth rate of China's real GDP and real GDP per capita averages at 9.92%⁶ and 8.69%⁷ respectively.

Figure 1 and figure 2 (in Appendix) shows real GDP and real GDP per capita in China from 1961 to 2007. Despite some small fluctuations, both figures generally present convex curves which mean the faster growth rate of real GDP and real GDP per capita as development of China. In order to study the above mentioned fluctuations more carefully, figure 3 and figure 4 (in Appendix) can be resorted for more detailed analysis. Figure 3 and figure 4 depict the growth rate of real GDP and real GDP per capita of China from 1961 to 2007 respectively. The two figures show the same trend

⁴ Data Source: World Development Indicators, the World Bank

⁵ Data Source: World Development Indicators, the World Bank

⁶ Data Source: World Development Indicators, the World Bank

⁷ Data Source: World Development Indicators, the World Bank

of economic growth of China during this period. Generally, it is notable that economic growth of China has distinct cycles and the cycles' period is rather narrow before 1977. After 1978, growth cycles become smooth, especially after 1992. This shows that from 1990's, China's economic growth has become more and more steady.

Although China's economic performance is extraordinary especially in the past thirty years, the mode of its growth is still be debated by many scholars. Some studies have pointed that China's economy grows in an inefficient way which mainly relies on large amount of capital inputs instead of progress of technology dominated in developed economies. According to Shen Kunrong (1996), he rests upon the formula of growth accounting⁸ and calculates the share of contribution from different variables in economic growth. The outcomes are listed in table 2.

Table 2 Factor Analysis of China's Economic Growth (%)

| Time Period | Economic Growth Rate | Growth Rate of Total Factor Productivity | Growth Rate of Capital Input | Growth Rate of Labour Input |
|--------------------|-----------------------------|---|-------------------------------------|------------------------------------|
| 1953-1993 | 7.1 (100) | 1.0 (14.1) | 10.3 (65.3) | 2.7 (20.6) |
| 1953-1978 | 6.0 (100) | 0.4 (6.7) | 9.3 (69.6) | 2.6 (23.7) |
| 1979-1993 | 9.2 (100) | 2.3 (25.0) | 12.0 (58.4) | 2.8 (16.6) |
| 1979-1984 | 8.3 (100) | 2.6 (31.3) | 8.8 (48.2) | 3.1 (20.5) |
| 1985-1990 | 8.5 (100) | 1.7 (20.0) | 11.7 (62.4) | 2.8 (17.6) |

⁸ See Equation (2)

| | | | | |
|-----------|-------|--------|--------|-------|
| 1991-1993 | 12.4 | 4.1 | 15.8 | 2.2 |
| | (100) | (33.1) | (57.1) | (9.8) |

Note: The numbers without parentheses are the growth rate contributed from different factors; the numbers within parentheses are share of contribution from different factors in economic growth.

Source: Table 2 is from Shen Kunrong (1996): China's Economic Growth Mode and Inflation

From Table 2, it is obvious that capital inputs contribute most in China's economic growth. Capital inputs contribute more than 60% among all the factors of growth during 1953-1993 on average. However, on the same period, the share of contribution from total factor productivity on economic growth only account for 14.1% on average. And the contribution from total factor productivity is mainly distinct after 1979 – the beginning of China's economic reforms and opening polices. It is interesting that the contribution from total factor productivity on growth surprisingly drops to 20% during 1985-1990. The explanation is that the drop is due to the explosive investment contributed to economic growth during this period, which amounts to 62.4%. The contribution of total factor productivity is up to 33.1% during 1991-1993, but this number is still much lower than that of the developed economies. Table 3 shows the international comparison in factor analysis on economic growth. It reveals that the listed economies in Table 3 all enjoy the biggest share of contribution from total factor productivity on their respective growth. Actually, if taking a vertical overview in history of economic development, world economy starts to accelerate growing from the first industrial revolution. It is obvious that technological advancement is the engine of this acceleration, which is also evidenced by the facts in Table 3 (except China).

Table 3 International Comparison in Factor Analysis on Economic Growth (%)

| Country (Time Period) | Share of contribution from Labour in growth | Share of contribution from capital in growth | Share of contribution from Total Factor Productivity in Growth |
|---|--|---|---|
| China (1953-1993) | 20.6 | 65.3 | 14.1 |
| Before Economic Reforms | 23.7 | 69.6 | 6.7 |
| During Economic Reforms | 16.6 | 58.4 | 25.0 |
| South Korea (1963-1971) | 37.39 | 23.81 | 38.79 |
| Japan (1953-1971) | 21.0 | 23.84 | 55.16 |
| the United States. (1948-1969) | 32.50 | 19.75 | 47.75 |
| Canada (1950-1967) | 37.37 | 23.03 | 39.60 |
| Federal Republic of Germany (1950-1962) | 21.85 | 22.49 | 55.66 |

Source: Table 3 is from Shen Kunrong (1996): China's Economic Growth Mode and Inflation

It also should be noted that the developed economies in Table 3 have a much even share of contribution from different factors on growth than China. For South Korea, the United States and Canada, the shares on growth contributed from labour inputs not only all exceed 30% but they are also larger than that from capital inputs for these countries. Obviously, the high share contribution from labour input is not due to the

growing number of labour but the high quality of labour force. In the study of Chen Qinghua et al. (2002), they also include Denison Factor Analysis Method besides Solow Residuals Method to sub-group the factors which contribute to economic growth. In their study, labour is further sub-grouped into quantity of labour force and quality of labour force (education level). The results of their studies support the main contribution on growth in China is from capital inputs, but also points that contribution from the quality of labour force in China is too limited especially compared with that of the United States.

Large amounts of capital inputs may boost the market and economy in a short time, but as the development of society, effects of science and technology are more and more important. Also, education level should be emphasized in order to catch up with technological progress by labour force. International experiences make many scholars caveat whether China's economic growth is sustainable even though it has achieved impressed growing rate. One of the problem under this kind of growth mode is that it will lead to inflation. Shen Kunrong (1996) argues that the growing demand of input of factors will lead to excess demand and supply shock. Then finally, demand-pull inflation will appear.

3.2 Inflation

Keeping fiscal and monetary policies steady have always been one of the most important macro-economic targets of the authority in China. From 1949 – the foundation of People's Republic of China until 1979 – the beginning of economic reforms and opening polices, China has been in a centrally planned and almost closed economy under which circumstance demand and supply are totally controlled by the central government, moreover international economic influence could be totally neglected at this time. During this period, inflation was tightly controlled by macro-economic polices of the government, therefore price level is generally stable

except for influence by some non-economic factors (such as Three-Year Natural Disaster and Cultural Revolution). From 1979, China has gradually transformed into market economy and controlling inflation has been an important task of the government as the high speed economic development which is lead by large amount of international investment's entering. Figure 5 (in Appendix) shows the inflation (Consumer Price Index Percentage Change) during 1979-2007 of China. Figure 5 shows that from 1979, frequencies and ranges of fluctuations of high inflation both is rather fierce. Zhang Chengsi (2009) studies inflation cycles of China during 1978-2008 and gives the explanations of high inflation fluctuations during each cycle in the context of China's economic reality at that time. For fluctuations from late 1970's until late 1980's, Zhang Chengsi (2009) concludes that the high inflation during this period is due to the differences between high demand shock and low supply shock which is generated by the high investment. The difference leads to the following price reforms, high pressure of money supply and etc., all of which finally contribute to the appearance of high inflation during this time. From 1992 to 1997, there is another round of fluctuation of high inflation, especially CPI in 1994 has increased by 24.08%⁹ compared to that of last year which is the highest annual percentage change of CPI from 1953. One of the main reasons for 1994's high CPI increase is the reform of exchange rate system of Chinese Yuan: from duo exchange rate system to single managed floating exchange rate system based on demand and supply of the market. The direct outcome of this reform is that it leads to the depreciation of Chinese Yuan. Zhang Chengsi (2009) points that the depreciation will make imported commodities more expensive and help to increase the cost of production and the price level generally. After 1997, price level has dropped sharply until 2002. From 2003, another round of inflation fluctuations comes. In 2004, CPI has increased by 3.9%¹⁰ compared to that of last year. Zhang Chengsi (2009) explains that the relative high CPI increase in 2004 is due to the increase price of real estate.

⁹ Data source: World Economic Outlook Database (updated in April, 2009), International Monetary Fund

¹⁰ Data source: World Economic Outlook Database (updated in April, 2009), International Monetary Fund

3.3 Capital Accumulation

At the same time, if attention is paid to capital accumulation, Figure 6 (in Appendix) gives the picture of gross fixed capital formation in China during 1966-2007. It shows that before 1977 the increase of capital is slow and limited, but from 1992 capital accumulation grows distinctly. The highest speed in capital accumulation happens after 2000. From the aspect of percentage change of gross fixed capital formation, Figure 7 (in Appendix) depicts a rather similar changing trend with those of growth rates of China's real GDP and real GDP per capita. It is not surprising to see the similarity because of high share contributed from capital inputs on growth in China as shown in Table 2 and 3. Furthermore, this similarity validate again that the mode of China's economic growth mainly depends on capital inputs in reality. But attention should be paid to that the range of the fluctuation of gross fixed capital formation growth is much larger than that of GDP growth and GDP per capita growth.

Figure 8 (in Appendix) depicts GDP per capita growth and CPI percentage change in one picture. Figure 8 shows that inflation change moves the same trend with economic growth after some time lags. If including the percentage change of capital accumulation and CPI percentage change in one picture, as shown in Figure 9 (in Appendix), same result that positive relationship between capital accumulation and inflation can be obtained. Because as mentioned above growth rate of capital accumulation moves almost the same way with economic growth, but its range is much larger.

4 Data and Descriptive Statistics

Three economic variables are adopted to detect inflation - economic growth relationship in this thesis. One is real GDP per capita (constant 2000 U.S. Dollars) of China from 1978 to 2007. The data of GDP per capita is from World Development

Indicators of the World Bank. The other one is CPI (Annual Average, year 2000=100) of China from 1978 to 2007. The data of CPI from 1980 to 2007 is from World Economic Outlook Database (Updated in April 2009) of International Monetary Fund, and CPI of year 1978 and 1979 is from the website of National Bureau of Statistics of China. All the data is annual time series.

As discussed in both theoretical and empirical studies on inflation - economic growth relationship, capital accumulation is not only a critical determinant variable for economic growth but always an important channel for inflation relating to economic growth¹¹. Therefore, besides exploring inflation - economic growth relationship, inflation – capital accumulation relationship will also be examined in the estimation part¹². This thesis will employ gross fixed capital formation as proxy indicating the third variable - capital accumulation. The annual time series data of gross fixed capital formation (constant 2000 U.S. Dollars) of China from 1978 to 2007 is obtained from World Development Indicators of the World Bank.

The three variables are to be transformed into the logarithmic form suggested by many previous literatures, such like Khan and Senhadji (2000). They summarize the advantages that logarithmic data can smooth data distribution to some extent¹³. They also mention that logarithmic form can have better goodness of fit for non-linearity¹⁴. The most important is taking the difference of variables can obtain their respective change rate. Then the relationships of inflation – economic growth and inflation – capital accumulation growth can be examined by the relationships shown in Equation (3a), (3b), (4a) and (4b)¹⁵ which will be used for on co-integration regression.

¹¹ See Fischer (1993)

¹² Thank Professor Lennart Schön's suggestion of inclusion of capital accumulation in this thesis.

¹³ See also Sarel (1996)

¹⁴ See also Ghosh and Phillips (1998)

¹⁵ See Engle – Granger (1987)

$$\log(GDPPC_t) = \alpha_1 + \beta_1 \log(CPI_t) + \varepsilon_{1t} \quad (3a)$$

$$\log(CPI_t) = \alpha_2 + \beta_2 \log(GDPPC_t) + \varepsilon_{2t} \quad (3b)$$

$$\log(CAP_t) = \alpha_3 + \beta_3 \log(CPI_t) + \varepsilon_{3t} \quad (4a)$$

$$\log(CPI_t) = \alpha_4 + \beta_4 \log(CAP_t) + \varepsilon_{4t} \quad (4b)$$

$\log(GDPPC_t)$ logarithmic real GDP per capita

$\log(CPI_t)$ logarithmic CPI

$\log(CAP_t)$ logarithmic Gross Fixed Capital Formation

ε_t random disturbance term

The descriptive statistics of GDP per capita, CPI and gross fixed capital formation are given in Table 4.

Table 4 Descriptive Statistics of GDP Per Capita, CPI and Gross Fixed Capital Formation (1978-2007)

| | log(GDPPC) | log(CPI) | log(CAP) |
|--------------|-------------------|-----------------|-----------------|
| Mean | 6.250764 | 4.034024 | 25.95414 |
| Median | 6.224776 | 4.073611 | 25.91991 |
| Maximum | 7.501634 | 4.733687 | 27.57802 |
| Minimum | 5.105945 | 3.058707 | 24.52759 |
| Std. Dev. | 0.727560 | 0.603386 | 0.956409 |
| Skewness | 0.029049 | -0.285596 | 0.09311 |
| Kurtosis | 1.798363 | 1.457877 | 1.730458 |
| Jarque-Bera | 1.809133 | 3.380506 | 2.058019 |
| Probability | 0.404717 | 0.184473 | 0.357361 |
| Sum | 187.5229 | 121.0207 | 778.6242 |
| Sum Sq. Dev. | 15.35095 | 10.55817 | 26.52681 |

Figure 10, 11 and 12 (in Appendix) depict the time series line charts of variables: $\log(\text{GDPPC})$, $\log(\text{CPI})$ and $\text{LOG}(\text{CAP})$ respectively. Apparently, all the variables are not stationary. Non-stationary time-series data can not be adopted in econometric estimation because it will violate the assumption of the regression model and gives spurious results. Generally differencing the time series variables will be adopted for dealing with non-stationary data. Firstly, the first order of difference of the variables¹⁶ will be needed to see whether this will eliminate the distinct time trend and make the data stationary¹⁷.

Furthermore, Figure 13 (in Appendix) which is the scatter graph of relationship between inflation and economic growth reveals a positive inflation - economic growth relationship. Another attention would be paid to Figure 14 (in Appendix) which depicts the scatter graph of inflation - capital accumulation growth relationship, the graph show also a positive relationship. However, all of the implications from Figure 13 and 14 is just an intuitionistic estimation from the raw data, and more information about relationship between inflation and economic growth, capital accumulation growth will be explored in econometric analysis part of this thesis.

¹⁶ $d\log(\text{GDPPC})$: The first difference of $\log(\text{GDPPC})$, i.e. the economic growth

$d\log(\text{CPI})$: The first difference of $\log(\text{CPI})$, i.e. the inflation rate

$d\log(\text{CAP})$: The first difference of $\log(\text{CAP})$, i.e. the grow rate of capital accmulation

¹⁷ This will be test in Unit Root Test in Section 5.

5 Methodology and Estimation

5.1 Unit Root Test, Correlation Matrix

For time series observations, one of the problems is the possibility of non-stationary data. If the time series data is non-stationary, the estimation will give spurious results. Therefore, it is necessary to apply Unit Root Test first before estimation to see whether the time series data is stationary or not. This thesis will adopt the ADF¹⁸ test (Dickey and Fuller, 1981) to test the property that whether the data is stationary. The results of Unit Root Test based on both level data and the first difference data are to be shown in Table 5. From the results of Table 5 combining the facts in Figure 11, 12 and 13, the three variables: log(GDPPC), log(CPI) and log(CAP) are not stationary but they are all integrated to order 1¹⁹. This also means that the first difference of the variables are stationary.

Table 5 The ADF Test Based on Both of Level and the First Difference of Data

| Variables | The ADF Test Statistics | | |
|-------------|-------------------------|--------------------------|----------------------------------|
| | With Intercept | With Intercept and Trend | Without both Intercept and Trend |
| log(GDPPC) | 0.607267 | -4.282549** | 3.31019 |
| log(CPI) | -0.733502 | -1.294825 | 1.664164 |
| log(CAP) | 0.588037 | -4.559395* | 4.314409 |
| dlog(GDPPC) | -3.557543** | -3.549617* | 0.318691 |
| dlog(CPI) | -2.947469* | -2.875951 | -1.878222* |

¹⁸ Augmented Dickey-Fuller (1981)

¹⁹ Integrated to order 1 can be written as I(1).

| | | | |
|------------------|---------------------|---------------------|-------------------|
| dlog(CAP) | -4.559395*** | -4.558635*** | -1.806765* |
|------------------|---------------------|---------------------|-------------------|

Notes: 1 *** , ** and * means significant at 1% , 5% and 10% significance level respectively.

2 The null hypothesis of ADF is that data has an unit root.

3 Lag length for ADF tests are chosen based on Schwarz Info Criterion.

Followed by Unit Root Test, there is a correlation matrix to detect the correlation among the three variables: dlog(GDPPC), ddlog(CPI) and dlog(CAP). Table 6 show the results. Same with the scatter graphs, the results find that positive correlation exist both between inflation and economic growth and between inflation and capital accumulation growth. But the correlation between capital accumulation growth and economic growth is very weak. Besides, it is not surprising that capital accumulation growth is closely positively correlated to economic growth with correlation coefficient of about more than 0.76. This approves the assertion by the study of Shen Kunrong (1996) that economic growth of China is driven mainly by large capital inputs.

Table 6 Correlation Matrix

| | dlog(CPI) | dlog(GDPPC) | dlog(CAP) |
|-------------|------------------|--------------------|------------------|
| dlog(CPI) | 1 | 0.148499 | 0.007084 |
| dlog(GDPPC) | 0.148499 | 1 | 0.756878 |
| dlog(CAP) | 0.007084 | 0.756878 | 1 |

5.2 Estimation of Lag Length Based on Vector Autoregression (VAR)

Model

Actually, for time series data, another problem is that the lagged observations of variables will also have impact on independent variables (i.e. autocorrelation). And the lagged observations may not only come from dependent variables but also from

independent variables. VAR model is a very important specification for time series data. The following adopted the Granger Causality Test, co-integration and error correction models are all based on VAR model. The reason of inclusion of VAR model here is that I will adopt VAR model to estimate the lag lengths of the variables. Because VAR model can give a more comprehensive evaluation of the lag lengths of the relationship between the variables. And the accurate selection of the lag length is very important to the Granger Causality Test, co-integration and error correction models which will be adopted in the latter part of this thesis.

The models of VAR models can be shown in Equation (5a), (5b), (6a) and (6b) at below.

$$d \log(GDPPC_t) = \alpha_1 + \sum_{i=1}^n \beta_{1i} d \log(CPI_{t-i}) + \sum_{i=1}^n \gamma_{1i} d \log(GDPPC_{t-i}) + e_{1t} \quad (5a)$$

$$d \log(CPI_t) = \alpha_2 + \sum_{i=1}^n \beta_{2i} d \log(GDPPC_{t-i}) + \sum_{i=1}^n \gamma_{2i} d \log(CPI_{t-i}) + e_{2t} \quad (5b)$$

$$d \log(CAP_t) = \alpha_3 + \sum_{i=1}^n \beta_{3i} d \log(CPI_{t-i}) + \sum_{i=1}^n \gamma_{3i} d \log(CAP_{t-i}) + e_{3t} \quad (6a)$$

$$d \log(CPI_t) = \alpha_4 + \sum_{i=1}^n \beta_{4i} d \log(CAP_{t-i}) + \sum_{i=1}^n \gamma_{4i} d \log(CPI_{t-i}) + e_{4t} \quad (6b)$$

n lag length

The choice of lag length is depending on five different criteria and the results can be found in Table 7 and 8. For the model of economic growth and inflation, the four tests out of five choose lag length of 2. But for the model of capital accumulation growth and inflation, three out of five suggest lag length of 5.

Table 7 VAR Lag Length Selection based on Equation (5a) and (5b)

| |
|--|
| VAR Lag Order Selection Criteria Endogenous variables: DLOGGDPPC DLOGCPI Exogenous variables: C |
|--|

Sample: 1978 2007

Included observations: 23

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|-----|----------|-----------|-----------|------------|------------|------------|
| 0 | 83.28550 | NA | 2.92e-06 | -7.068304 | -6.969566 | -7.043472 |
| 1 | 103.3555 | 34.90430 | 7.24e-07 | -8.465693 | -8.169477 | -8.391196 |
| 2 | 110.4932 | 11.17208* | 5.57e-07* | -8.738539 | -8.244845* | -8.614376* |
| 3 | 112.6667 | 3.024041 | 6.70e-07 | -8.579715 | -7.888545 | -8.405888 |
| 4 | 117.0171 | 5.296112 | 6.82e-07 | -8.610183 | -7.721535 | -8.386690 |
| 5 | 121.3775 | 4.550000 | 7.18e-07 | -8.641523 | -7.555398 | -8.368366 |
| 6 | 126.9338 | 4.831578 | 7.15e-07 | -8.776855* | -7.493253 | -8.454033 |

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 8 VAR Lag Length Selection based on Equation (6a) and (6b)

VAR Lag Order Selection Criteria

Endogenous variables: DLOGCPI DLOGCAP

Exogenous variables: C

Sample: 1978 2007

Included observations: 23

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|-----|----------|-----------|-----------|------------|------------|------------|
| 0 | 55.57666 | NA | 3.25e-05 | -4.658840 | -4.560101 | -4.634007 |
| 1 | 76.46212 | 36.32254 | 7.51e-06 | -6.127141 | -5.830925 | -6.052643 |
| 2 | 80.68561 | 6.610686 | 7.44e-06 | -6.146575 | -5.652882 | -6.022412 |
| 3 | 87.00182 | 8.787768 | 6.24e-06 | -6.347984 | -5.656814 | -6.174157 |
| 4 | 98.62845 | 14.15416 | 3.38e-06 | -7.011170 | -6.122522 | -6.787677 |
| 5 | 110.5990 | 12.49097* | 1.83e-06* | -7.704258 | -6.618133* | -7.431100 |
| 6 | 115.4388 | 4.208522 | 1.94e-06 | -7.777284* | -6.493681 | -7.454461* |

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

5.3 Granger Causality Test

As the variables of $d\log(\text{GDPPC})$, $d\log(\text{CPI})$ and $d\log(\text{CAP})$ have been tested to be stationary in Unit Root Test above. The Granger Causality Test can be adopted to further detect the nature of relationships both between inflation and economic growth and inflation and capital accumulation growth. Granger Causality Test provide important information of the causal direction between the variables. The knowledge of knowing the causal direction can make the economic variables more effectively controlled to maximize the profits of the public. Results about relationships both between inflation and economic growth and between inflation and capital accumulation growth with the Granger Causality are given in Table 9 and 10.

Table 9 Pairwise Granger Causality Tests

| Null Hypothesis | F-Statistic | Prob. |
|--|--------------------|--------------|
| $d\log(\text{GDPPC})$ does not Granger Cause $d\log(\text{CPI})$ | 7.41256 | 0.0035 |
| $d\log(\text{CPI})$ does not Granger Cause $d\log(\text{GDPPC})$ | 5.65365 | 0.0104 |

Notes: Sample: 1978-2007; Lags: 2; Observations: 27.

Table 9 show that the hypothesis that $d\log(\text{GDPPC})$ does not Granger Cause $d\log(\text{CPI})$ is rejected significantly at 1% significance level and the hypothesis that $d\log(\text{CPI})$ does not Granger Cause $d\log(\text{GDPPC})$ is rejected significantly at 5% significance level. This means that there is a bi-causal direction between inflation and economic growth in China. For China, fast economic growth will lead to inflation and caution should be taken that when stabilizing the price level by reducing CPI, there would be harmful to growth.

Table 10 Pairwise Granger Causality Tests

| Null Hypothesis | F-Statistic | Prob. |
|--|--------------------|--------------|
| dlog(CAP) does not Granger Cause dlog(CPI) | 4.61361 | 0.0122 |
| dlog(CPI) does not Granger Cause dlog(CAP) | 13.9279 | 0.00008 |

Notes: Sample: 1978-2007; Lags: 5; Observations: 24.

Table 10 show that the hypothesis that dlog(CAP) does not Granger Cause dlog(CPI) is rejected significantly at 5% significance level and the hypothesis that dlog(CPI) does not Granger Cause dlog(CAP) is rejected significantly at 1% significance level. The inflation and capital accumulation growth also affect each other in two directions. High inflation will increase the capital accumulation but reducing price level will cause the lost of investment.

5.4 Co-Integration and Error Correction Model (ECM)

Co-integration

Co-Integration and Error Correction Models (ECM) are to be adopted in this thesis because they will not only detect the studied relationships but also reveal whether the relationships exist in the long-run. One of the assumptions of the traditional econometric estimation methods is that the property of data is stationary. But in fact, most of the economic variables may not hold for this property. Then the inconsistency between assumption and reality will cause a lot of problems in estimation (such as giving spurious results). In real economy, many economic variables are not stationary and usually have a distinct time trend. But they still may have a long-run equilibrium

relationship. The basic models adopted in this thesis shown in (3a), (3b), (4a) and (4b) are hypothesized upon that the two sets of bi-variant variables have the long-run equilibrium relationship. And the hypotheses are based on the co-integrating property of data. That means if the variables are proved to be co-integrated, then they have the long-run equilibrium relationship. Then how to decide whether the variables have the long-run equilibrium relationship is a critical problem. The Engle – Granger (1987) two-step co-integration procedure is one of the new methods for testing the possibility of co-integration of the variables.

The test whether the variables are integrated to the same order is the sufficient condition of co-integration. In the Unit Root Test in the Section 5.1, it is evidenced that GDP per capita, CPI and gross fixed capital formation are all integrated to order one²⁰. Upon the condition, the Engle – Granger (1987) two – step co-integration procedure could be followed to test whether the two sets of variables are co-integrated with each other or not. Engle and Granger (1987) point that if the variables are integrated to the same order, then their linear combination could have the possibility to be stationary. And the assumption of the stationary linear combination is that the random disturbance term should be stationary. That means the random disturbance term should have the property of white noise then in the long run the disturbance will be canceled by each other and the long-run equilibrium between the variables will not be destroyed. The basic models of this thesis shown in (3a), (3b), (4a) and (4b) are hypothesized upon the fact that the variables are co-integrated. To test this, the first step of the Engle – Granger (1987) two – step co-integration procedure is to estimate Equation (3a), (3b), (4a) and (4b) by Ordinary Least Squares (OLS)²¹. Followed by estimations with OLS, the second step of the Engle – Granger (1987) two – step co – integration procedure is that Unit Root Tests are conducted on the residuals of each OLS regression models and the results are given in Table 11. The results show the residuals of equations of (3a) and (3b) are both stationary and that means the variables

²⁰ I(1)

²¹ The results of OLS are shown in Table A1, A2, A3 and A4 in Appendix.

of $\log(\text{GDPPC})$ and $\log(\text{CPI})$ are co-integrated and have a long-run equilibrium relationship. However, the residuals of equations of (4a) and (4b) are non-stationary and have a unit root and then the variables of $\log(\text{CAP})$ and $\log(\text{CPI})$ are not co-integrated and do not have the long-run equilibrium relationship. Then the hypotheses of the basic model of this thesis shown in (3a), (3b) will hold in but (4a) and (4b) can not hold in the long run. The method of the Engle – Granger (1987) two – step co-integration procedure is useful and effective for bi-variant variables. If there are more than two variables in the model, Johansen Test will be adopted. Johansen Test is a more general test for con-integration, because it will be restricted by the number of variables. Johansen (1988), Johansen and Juselius (1990) adopt maximum likelihood method to estimate the number of co-integrating vectors (or equations). There are three possibility of the number of co-integration vectors (or equations) among the variables: (a) $r=0$: there is no co-integration vector among the variables, and that means the variables are not co-integrated; (b) $r=m$ (m is the number of variables in the model): there are m co-integrating vectors among the variables; (b) $0 < r \leq m - 1$ (m is the number of variables in the model): there is r co-integrating vectors among the variables, and that means there are r stationary linear combination in the model²². In the Johansen Test, two types of maximum likelihood ratio tests will be adopted. The two sets of bi-variables based on Equation (3a), (3b), (4a) and (4b) will be testified under the Johansen Test and Table 12 and Table 13 show the details. The results by the Johansen Test show that the null hypothesis of $r=0$ can be rejected at 1% significance level for the sets of bi-variables based on Maximum Eigen Value Test and Trace test respectively. That means the variables of GDP per capita and CPI are co-integrated. But for the set of variables of CPI and gross fixed capital formation, the null hypothesis of $r=0$ can not be rejected. There is no long-run equilibrium between the variables. The results from the Johansen Test is line with that from the Engle – Granger (1987) two-stage co-integration procedure.

²² See Li Zinai and Ye Azhong (2000)

Table 11 Unit Root Tests on the Residuals based on Equation (3a), (3b), (4a) and (4b) with ADF, PP and KPSS

| Variable | the ADF Test |
|----------|--------------|
| (4a) | I(0)** |
| (4b) | I(0)** |
| (5a) | I(1)** |
| (5b) | I(1)** |

Notes: 1 *** means significant at 1% significance level, and ** means significant at 5% significance level.

2 The null hypothesis of ADF is data has an unit root

3 Lag length for ADF tests are chosen based on Schwarz Info Criterion.

Table 12 Johansen Test based on Maximum Eigen Value Test

| Variable | Null Hypothesis | Eigen Value | 0.05 Critical Value |
|----------------------------|-----------------|-------------|---------------------|
| log(CPI) and log(GDPPC) | $r=0$ | 0.947669 | 14.26460*** |
| | $0 < r \leq 1$ | 0.774407 | 3.841466*** |
| log(CPI) and log(CAP) | $r=0$ | 0.213272 | 14.26460 |
| | $0 < r \leq 1$ | 0.019267 | 3.841466 |

Notes: 1 *** means significant at 1% significance level

2 The lag length of each set of bi-variables is based on VAR Lag Length Selection

Table 13 Johansen Test based on Trace Test

| Variable | Hypothesis | Eigen Value | 0.05 Critical Value |
|----------------------------|----------------|-------------|---------------------|
| log(CPI) and log(GDPPC) | $r=0$ | 0.947669 | 15.49471*** |
| | $0 < r \leq 1$ | 0.774407 | 3.841466*** |
| log(CPI) and log(CAP) | $r=0$ | 0.213272 | 15.49471 |
| | $0 < r \leq 1$ | 0.019267 | 3.841466 |

Notes: 1 *** means significant at 1% significance level

2 The lag length of each set of bi-variables is based on VAR Lag Length Selection

Error Correction Models (ECM)

The variables between GDP per capita and CPI have been proven to be co-integrated and they have a long-run equilibrium relationship. But in the short run, the disequilibrium still exists but the disequilibrium will be corrected in the long run. The Error Correction model is to be developed to detect this process and contains both the short-run and long-run information in one model.

$$\Delta \log(GDPPC) = \sum_{i=0}^p \beta_i \Delta \log(CPI)_{t-i} + \sum_{j=1}^q \phi_j \Delta \log(GDPPC)_{t-j} + \theta ECM + \varepsilon_t \quad (7a)$$

$$d \log(GDPPC) = \sum_{i=0}^p \log(CPI)_{t-i} + \sum_{j=1}^q \phi_j \Delta \log(GDPPC)_{t-j} + \theta ECM + \varepsilon_t$$

$$\Delta \log(CPI) = \sum_{i=0}^p \beta_i \Delta \log(GDPPC)_{t-i} + \sum_{j=1}^q \phi_j \Delta \log(CPI)_{t-j} + \theta ECM + \varepsilon_t \quad (7b)$$

Δ the first difference

ECM error correction term

p, q lag length

ε_t random disturbance term

$0 < \theta \leq 1$

Equation (7a)²³ and (7b)²⁴ are error corrections models based on Equation (3a) and (3b). ECM is the residuals of Equation (5a) and (5b). As the bi-variable in (3a) and (3b) have the long-run equilibrium, then ECM in (7a) and (7b) should have the property of white noise, i.e. ECM should be stationary. Then co-integration test and

²³ Mallik and Chowdhury (2001), pp. 127

²⁴ Mallik and Chowdhury (2001), pp. 127

error correction models are connected in one specification. Table 14 shows the results of error correction models based on (7a) and (7b). The coefficients of ECM of (7a) and (7b) are all positive which means if there is short-run disequilibrium shock between inflation and economic growth, the error correct term will increase to eliminate the shock and keep the long-run equilibrium between the two variables. If there is a short-run disequilibrium between inflation and economic growth in year t of China, 0.02% economic growth or 0.07% inflation will be corrected in the next year. The degree of correction mechanism is not powerful.

Table 14 Error Correction Model

| Error Correction: | D(LOGGDPPC) | D(LOGCPI) |
|--------------------------|--------------------|-------------------|
| ECM | 0.020486 | 0.068028 |
| | -0.01868 | -0.0439 |
| | [1.09661] | [1.54959] |
| D(LOGGDPPC(-1)) | 1.03097 | 1.632767 |
| | -0.17991 | -0.42279 |
| | [5.73049] | [3.86192] |
| D(LOGGDPPC(-2)) | -0.437605 | -0.8018 |
| | -0.17927 | -0.42128 |
| | [-2.44103] | [-1.90323] |
| D(LOGCPI(-1)) | -0.221403 | 0.566734 |
| | -0.06784 | -0.15943 |
| | [-3.26348] | [3.55477] |
| D(LOGCPI(-2)) | 0.197442 | 0.244592 |
| | -0.07552 | -0.17747 |
| | [2.61446] | [1.37822] |
| C | 0.036153 | -0.06254 |
| | -0.01345 | -0.03161 |
| | [2.68780] | [-1.97854] |

Note: Standard errors in () & t-statistics in []

6 Conclusions

This thesis tries to reveal the nature of inflation-economic growth relationship of China from 1978 to 2007. Previous literature has shown the complexity of the problem and still does not give an unambiguous conclusion between the two variables.

Previous studies show that inflation-economic growth relationship is sensitive to a lot of factors, such as the characteristics of sample country, the selection of sampling period and etc. That is why there is always a lot of studies trying to explore the relationship.

Empirical studies show that China has achieved its high speed economic growth mainly relying on the large amounts of capital inputs. And neo-classical theory has pointed that growth of capital accumulation is one of the determinant of economic growth. Also Fischer (1993) has evidenced that capital accumulation is one of the channel that inflation relate to economic growth. Therefore, in this thesis I also tries to detect whether there is relationship between inflation and capital accumulation growth besides the main work on inflation-economic growth relationship.

I rest upon correlation matrix, Granger Causality Test and co-integration and error correction models to reveal the nature of relationships both between inflation and economic growth and between inflation and capital accumulation growth step by step. Correlation coefficients and Granger Causality Test tell that inflation both relate to economic growth and capital accumulation and the causal direction of both of the two relationship is two-way. Although capital accumulation growth is a channel that inflation is conducive to economic growth, the degree is not that distinct. However, in the analysis of co-integration and error correction models, results show that only inflation and economic growth has the long-run positive equilibrium relationship. The short-run disequilibrium will be eliminated by increasing the error correction term in the next period. For capital accumulation growth, there is no long-run relationship with inflation but will correlate to economic growth in the short run.

The results give some very important implications to macro-economic policies of China. The long-run positive bi-directional causal relationship between inflation and economic growth show that China should control the level of inflation as the high speed development of economy. On the other hand, it should be noted that economic growth

would be slowed when stabilizing the price level by lowering CPI. At the same time, cautions should be put on high speed of growth of investment which will promote price level in the short run.

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Appendix

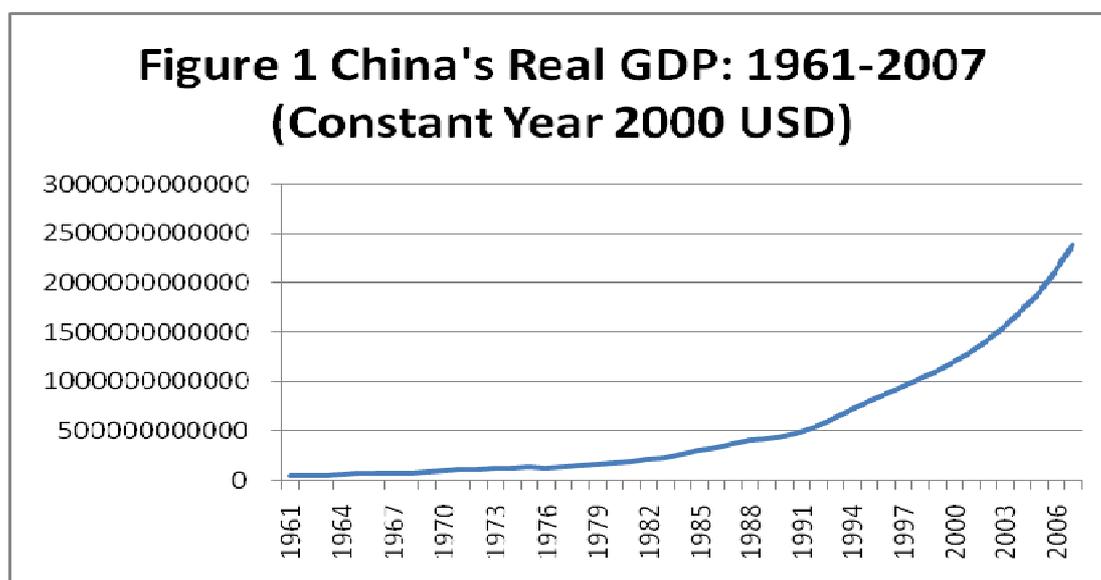


Figure 1 China's Real GDP: 1961-2007 (Constant Year 2000 USD)

Data source: World Development Indicators, the World Bank

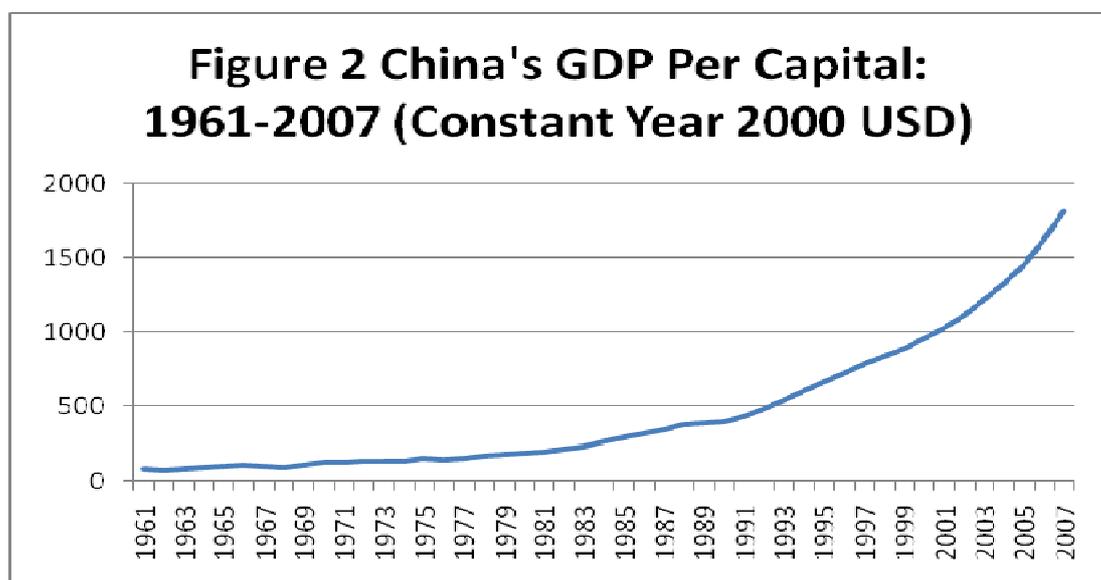


Figure 2 China's Real GDP Per Capita: 1961-2007 (Constant Year 2000 USD)

Data source: World Development Indicators, the World Bank

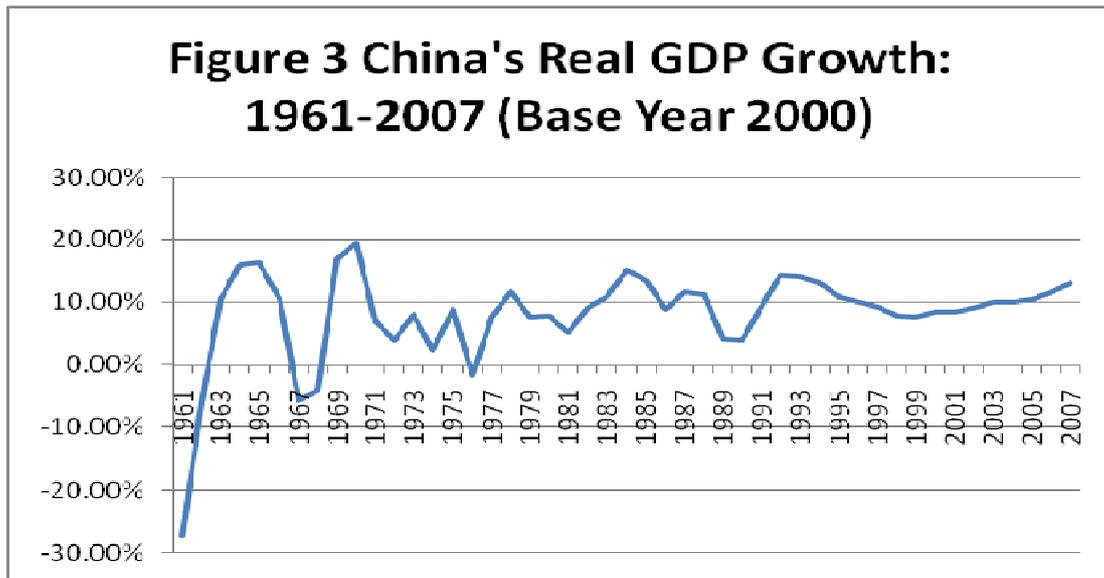


Figure 3 China's Real GDP Growth: 1961-2007 (Base Year 2000)

Data source: World Development Indicators, the World Bank



Figure 4 China's Real GDP Per Capita Growth: 1961-2007 (Base Year 2000)

Data source: World Development Indicators, the World Bank

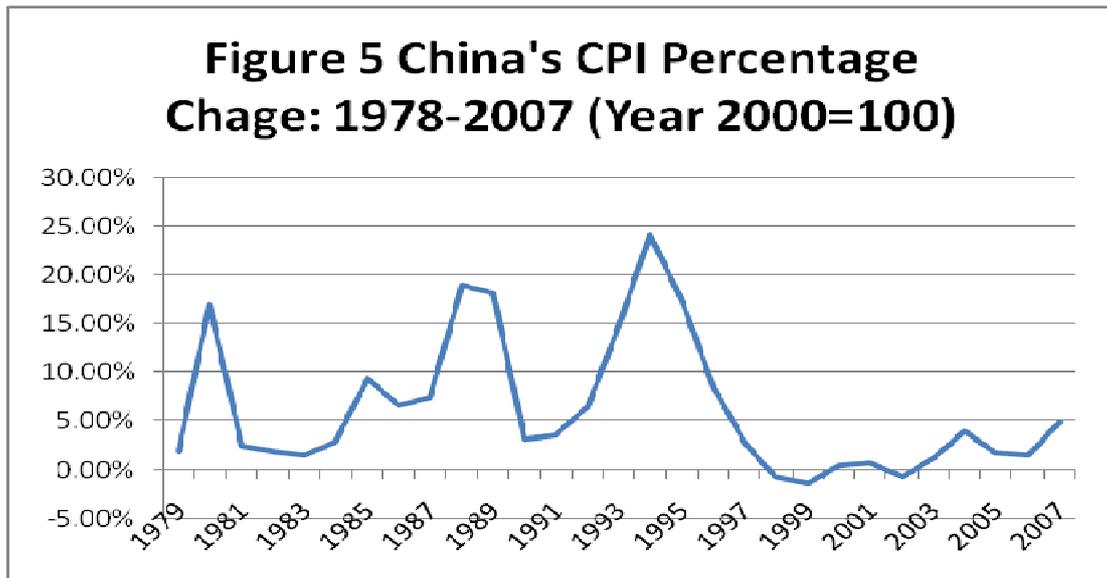


Figure 5 China's CPI Percentage Change: 1979-2007 (Year 2000=100)

Data source: World Economic Outlook Database (updated in April, 2009),
International Monetary Fund
National Bureau of Statistics of China

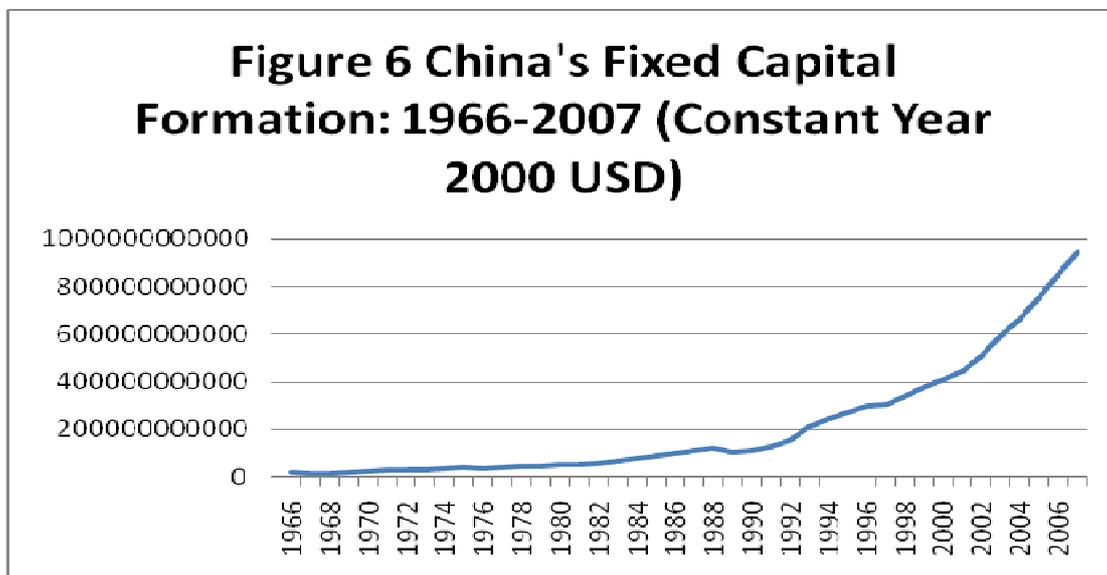


Figure 6 China's Gross Fixed Capital Formation: 1966-2007 (Constant Year 2000 USD)

Data source: World Development Indicators, the World Bank

Figure 7 China's Percentage Change of Gross Fixed Capital Formation: 1966-2007 (Base Year 2000)

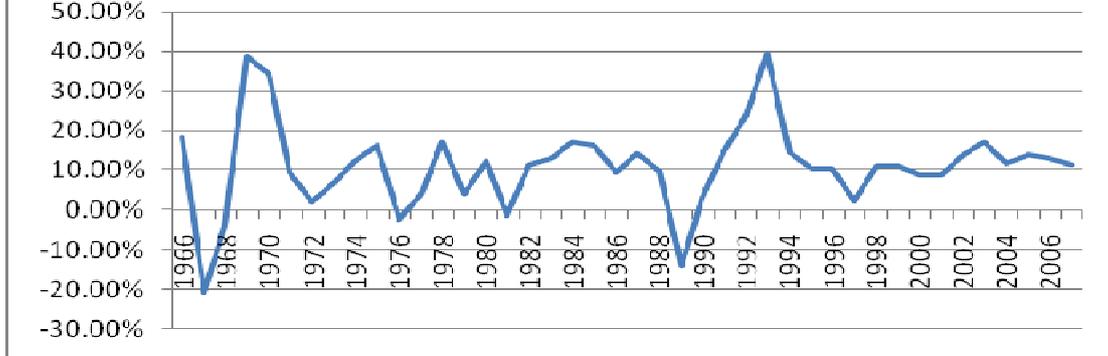


Figure 7 China's Percentage Change of Gross Fixed Capital Formation: 1966-2007 (Base Year 2000)

Data source: World Development Indicators, the World Bank

Figure 8 Comparison between Economic Growth and Inflation

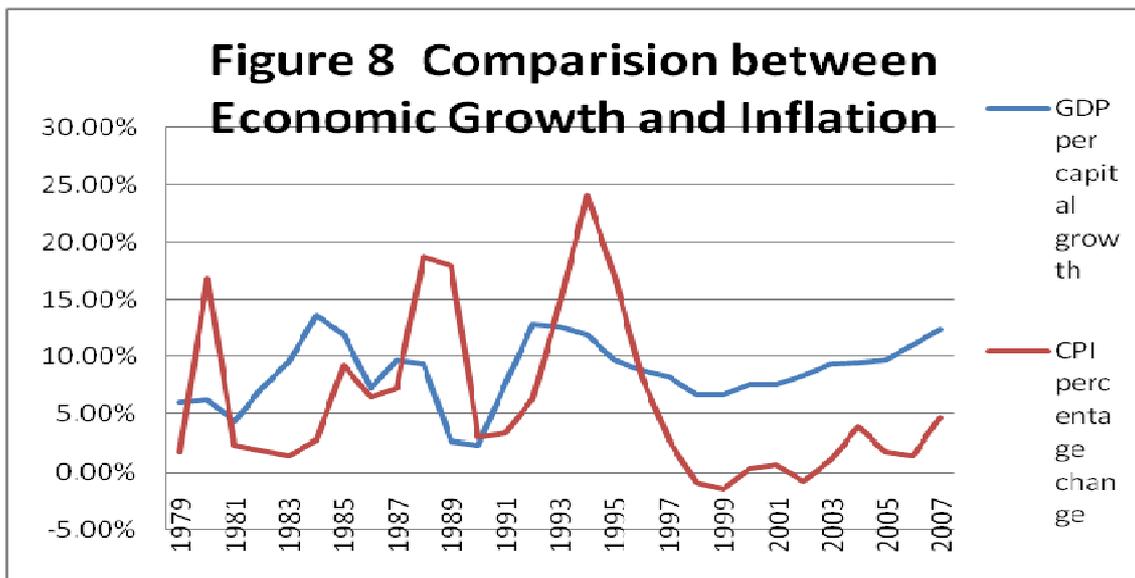


Figure 8 Comparison between Economic Growth and Inflation

Data source: World Development Indicators, the World Bank

World Economic Outlook Database (updated in April, 2009),
 International Monetary Fund
 National Bureau of Statistics of China

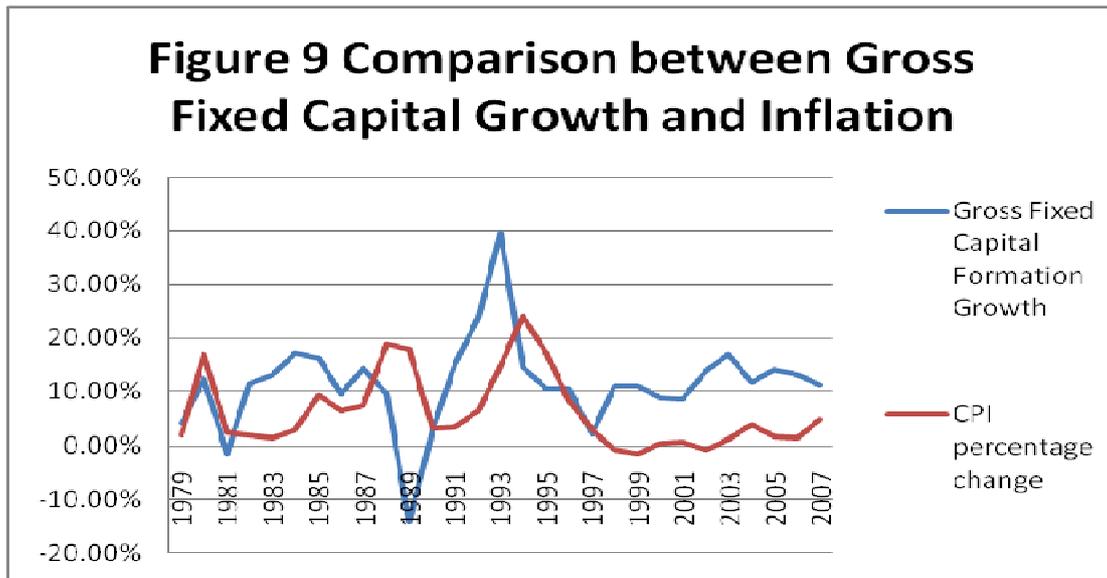


Figure 9 Comparison between Gross Fixed Capital Formation Growth and Inflation

Data source: World Development Indicators, the World Bank

World Economic Outlook Database (updated in April, 2009),

International Monetary Fund

National Bureau of Statistics of China

Figure 10 Line Chart of LOGGDPPC

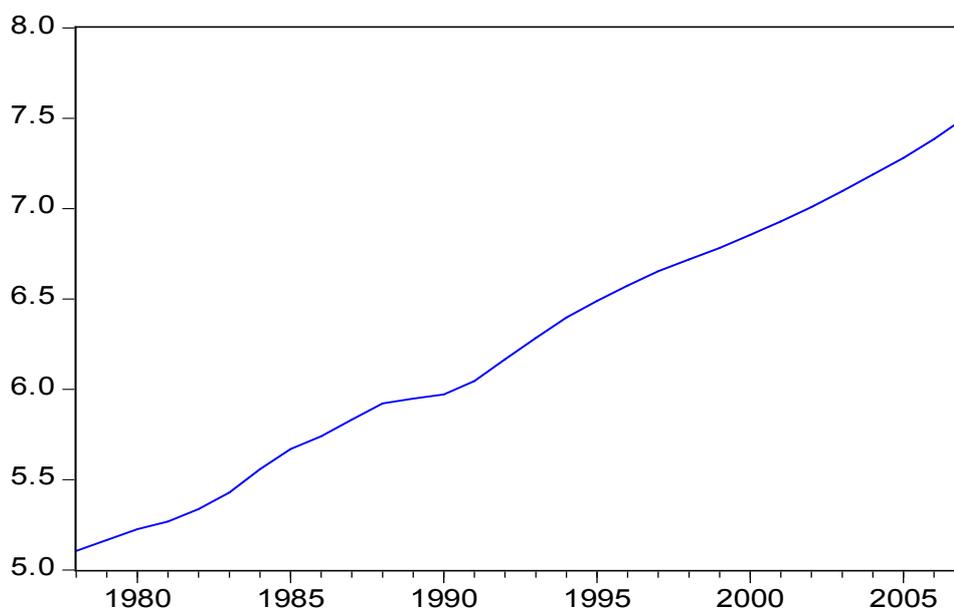


Figure 10 Line chart of Log Real GDP per capita

Figure 11 LOGCPI

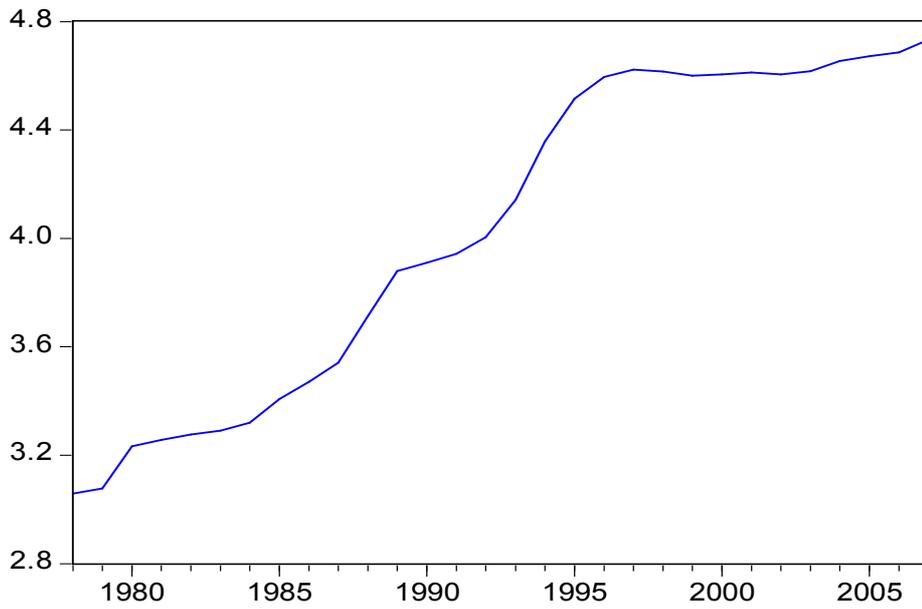


Figure 11 Line chart of Log CPI

Figure 12 LOGCAP

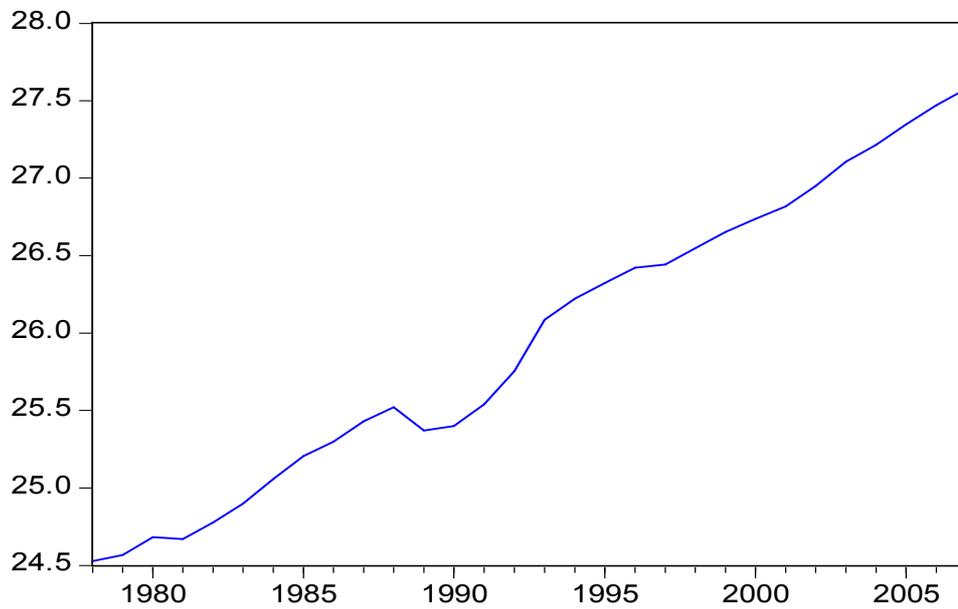


Figure 12 Figure 11 Line chart of Log CAP

Figure 13 Scatter Graph of Relationship between dlogGDPPC and dlogCPI

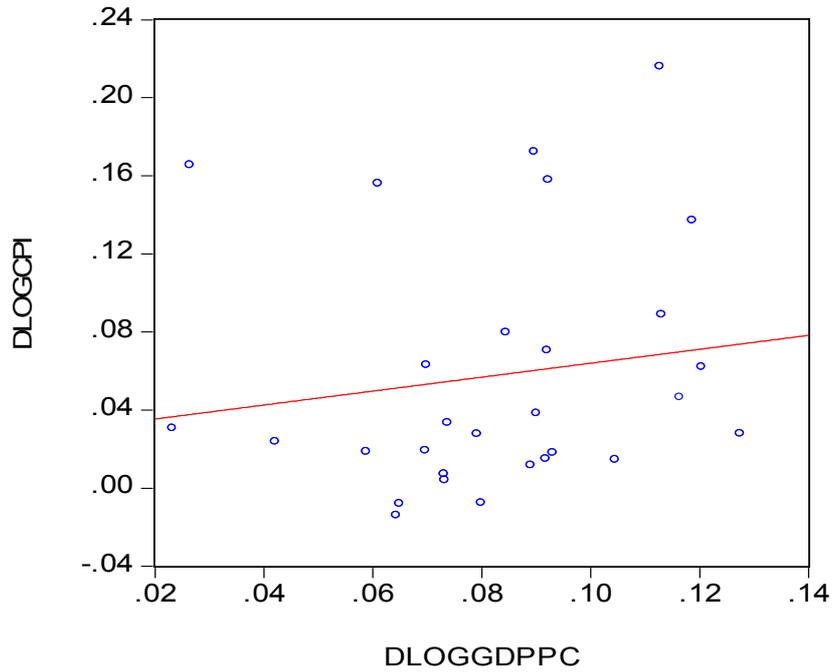


Figure 13 Scatter Graph of Relationship between dlogGDPPC and dlogCPI

Figure 14 Scatter Relationship of relationship between dlogCAP and dlogCPI

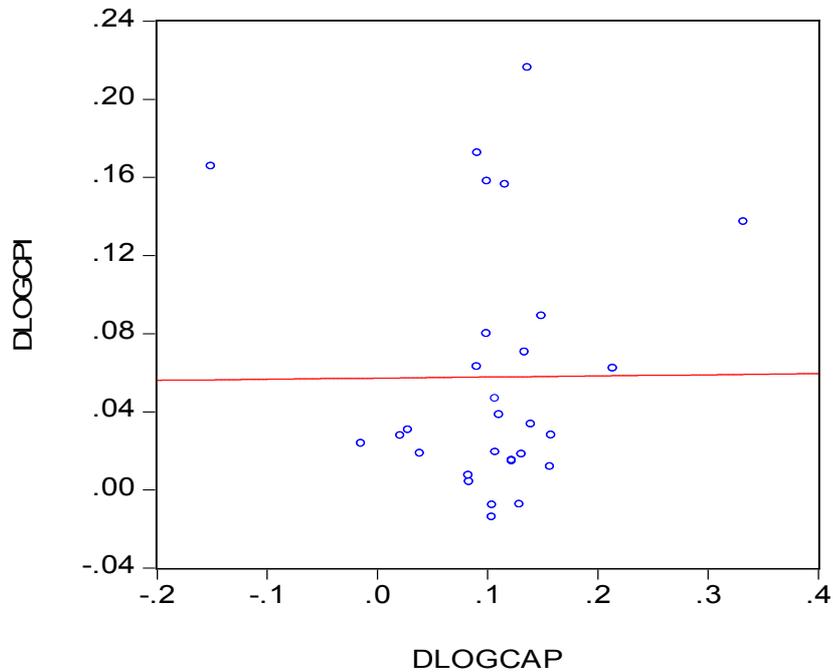


Figure 14 Scatter Relationship of relationship between dlogCAP and dlogCPI

Table A1 OLS Estimation based on Equation (3a)

| | | | | |
|------------------------------|-------------|-----------------------|-------------|----------|
| Dependent Variable: LOGGDPPC | | | | |
| Method: Least Squares | | | | |
| Sample: 1978 2007 | | | | |
| Included observations: 30 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LOGCPI | 1.541331 | 0.013437 | 114.7057 | 0.0000 |
| R-squared | 0.829872 | Mean dependent var | | 6.250764 |
| Adjusted R-squared | 0.829872 | S.D. dependent var | | 0.727560 |
| S.E. of regression | 0.300093 | Akaike info criterion | | 0.463317 |
| Sum squared resid | 2.611619 | Schwarz criterion | | 0.510023 |
| Log likelihood | -5.949752 | Hannan-Quinn criter. | | 0.478259 |
| Durbin-Watson stat | 0.101471 | | | |

Table A2 OLS Estimation based on Equation (3b)

| | | | | |
|----------------------------|-------------|-----------------------|-------------|-----------|
| Dependent Variable: LOGCPI | | | | |
| Method: Least Squares | | | | |
| Sample: 1978 2007 | | | | |
| Included observations: 30 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LOGGDPPC | 0.647363 | 0.005644 | 114.7057 | 0.0000 |
| R-squared | 0.896110 | Mean dependent var | | 4.034024 |
| Adjusted R-squared | 0.896110 | S.D. dependent var | | 0.603386 |
| S.E. of regression | 0.194483 | Akaike info criterion | | -0.404177 |
| Sum squared resid | 1.096887 | Schwarz criterion | | -0.357471 |
| Log likelihood | 7.062659 | Hannan-Quinn criter. | | -0.389235 |
| Durbin-Watson stat | 0.101706 | | | |

Table A3 OLS Estimation based on Equation (4a)

| | | | | |
|----------------------------|--|--|--|--|
| Dependent Variable: LOGCAP | | | | |
| Method: Least Squares | | | | |

| | | | | |
|---------------------------|-------------|-----------------------|-------------|----------|
| Sample: 1978 2007 | | | | |
| Included observations: 30 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LOGCPI | 6.329795 | 0.131899 | 47.98954 | 0.0000 |
| R-squared | -8.486138 | Mean dependent var | | 25.95414 |
| Adjusted R-squared | -8.486138 | S.D. dependent var | | 0.956409 |
| S.E. of regression | 2.945698 | Akaike info criterion | | 5.031334 |
| Sum squared resid | 251.6370 | Schwarz criterion | | 5.078040 |
| Log likelihood | -74.47001 | Hannan-Quinn criter. | | 5.046276 |
| Durbin-Watson stat | 0.026271 | | | |

Table A4 OLS Estimation based on Equation (4b)

| | | | | |
|----------------------------|-------------|-----------------------|-------------|----------|
| Dependent Variable: LOGCPI | | | | |
| Method: Least Squares | | | | |
| Sample: 1978 2007 | | | | |
| Included observations: 30 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LOGCAP | 0.156018 | 0.003251 | 47.98954 | 0.0000 |
| R-squared | 0.412549 | Mean dependent var | | 4.034024 |
| Adjusted R-squared | 0.412549 | S.D. dependent var | | 0.603386 |
| S.E. of regression | 0.462468 | Akaike info criterion | | 1.328285 |
| Sum squared resid | 6.202411 | Schwarz criterion | | 1.374991 |
| Log likelihood | -18.92427 | Hannan-Quinn criter. | | 1.343226 |
| Durbin-Watson stat | 0.026665 | | | |