THE LARGE DECLINE IN OUTPUT VOLATILITY: EVIDENCE FROM CHINA

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Abstract of a thesis submitted in partial fulfillment of the
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Since the founding of the People's Republic of China in 1949, China has experienced ten business cyclical fluctuations. The economic growth was characterized by erratic ups and downs which lasted for several decades. With the economic reform and opening up to the outside world in 1978 as part of Deng Xiaoping's market-oriented policy, the Chinese economy grew exponentially and the volatility of the GDP growth rate declined significantly. The macroeconomic control policies in the 1980s prevented large fluctuations in the country's economic development, and smoothed the output volatility further.

This study examines the output volatility in China and our result reveals the standard deviation of quarterly output growth rate has declined dramatically. Using the CUSUM squares test and the Quandt-Andrews breakpoint test to identify unknown structure breaks, we identified two structural breaks: 1994:1 towards destabilization and 1998:1 towards stabilization. We then examine the stochastic process for GDP and the result shows that the decrease in volatility can be traced primarily to a decrease in the standard deviation of output shocks. Following this, we reached two

other conclusions. First, there is a strong relationship between movements in output volatility and the movements in inflation volatility. Both output and inflation volatilities increased significantly during the third and fourth quarter of 1994 and both dropped sharply after 1996, which followed a similar path over the period. Second, using the standard decomposition of GDP, the decrease in output volatility can be traced to a decrease in the volatility of consumption, investment, and net export, especially rural consumption expenditure and residential investment.

Keywords: output volatility, structural break, output process, inflation volatility, GDP components.

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Chapter 1

INTRODUCTION

1.1 Introduction

Over the past few decades, there has been a sharp decline in macroeconomic volatility in most of the industrialized nations. The timing and nature of the decline differed across countries, and this moderation in volatility is widely known as *"The Great Moderation"*. A growing body of literature on Great Moderation has focused on the experience of G7 nation's[1] and provided possible explanations. For example, Kim and Nelson (1999) and McConnell and Perez-Quiros's (2000) studies showed there was a sharp reduction in the volatility of U.S. real GDP growth rate since the first quarter of 1984. Blanchard and Simon (2001), Summers (2005), and Stock and Watson (2003) documented similar declines in the volatility of output in other G-7 countries and Australia. The Federal Reserve Chairman, Mr. Bernanke (2004) also commented on the decline in the variability of both output and inflation in the U.S and argued that improvements in monetary policy have been an important source of the Great Moderation.

The decline in macroeconomic volatility has many potential benefits. For example, a lower volatility in inflation improves the market operation, makes economic planning less cumbersome and reduces the resources allocated to hedging inflation risks. With

[1] These are France, Italy, United Kingdom, Canada, Germany, Japan, and United States.

a lower volatility in output, the employment will be more stable, and the households and firms face less economic uncertainty. In addition, the length of business-cycle expansions become longer and recessions become shorter and less frequent since the start of Great Moderation.

However, there have been only a few studies examining such macroeconomic structural changes in developing countries. For example, Mohan (2007) compared the inflation volatility in developing countries after the Asian financial crisis (1998-2007) with the 30 preceding years (1970-1997). Mohan's result showed the average inflation as measured by the Consumer Price Index (CPI) in developing economies declined from 31.0 per cent to 7.0 per cent, and the inflation volatility measured in terms of coefficient of variation has fallen from 0.54 to 0.32. Gregorio (2008) argued that in developing countries the Great Moderation was achieved about ten years ago and coincidentally with the conquest of low inflation. This is mainly because reforms regarding monetary policy have lagged noticeably among developing economies. Central bank independence, inflation targeting and other related policy reforms have only occurred in developing economies in the mid-1990s, which coincides with the fall in volatility in these countries. In addition, Gregorio pointed out the timing of events supports the hypothesis of a causal relationship from inflation control to decreased output and inflation volatility. Hakura (2007) showed the volatility of output growth in emerging market and developing countries has declined in recent years. However, there are large differences between the regions. In South Asia and

China, the Middle East and North Africa, and the CFA Franc Zone countries in Sub-Saharan Africa, volatility has shown a sustained decline. In Latin America, the output volatility has remained constant at a relatively high level, and in East Asia it has increased since 1997. On average, countries in Asia had the lowest output volatility, and countries in Sub-Saharan Africa had the highest output volatility over the 1970–2003 period.

1.2 Background

Since the founding of the People's Republic of China in 1949, China has experienced ten business cyclical fluctuations. The economic growth was characterized by erratic ups and downs which lasted for several decades. Higher volatility generates more risk in economic growth, and makes it more difficult for the Chinese government to establish optimum economic policies. China became an economic powerhouse in Asia with the economic reform and opening up to the outside world in 1978 as part of Deng Xiaoping's market-oriented policy. The Chinese economy grew exponentially and the volatility of the GDP growth rate declined significantly. In addition, the macroeconomic control policies in the 1980s prevented large fluctuations in the country's economic development, and smoothed the output volatility further. For example, Liu (2004) reported that the macroeconomic volatility of China's post reforms and openness decreased dramatically, and the period of expansion became longer compared to earlier decades. However, Liu did not analyze nor discuss this macroeconomic phenomenon in greater details.

1.3 Problem Statement

Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) were the pioneer researchers to identify the Great Moderation in volatility. They independently agreed that there was a sharp break in the volatility of the U.S. GDP growth in the first quarter of 1984. Their studies have been replicated in recent literature that characterizes this decline in volatility and its possible explanations.

There is a substantial amount of research on *"The Great Moderation"* using the U.S. data. Some researchers have been carried out outside the U.S., for example, France, Italy, United Kingdom, Canada, Germany, Japan, and Australia, but the study is still limited especially for the Asian countries. In addition, the evidence from the U.S. cannot be applied to other countries owing to the differences in economic development experience, the regulatory environment and the social system. Furthermore, most of the studies on decline in output volatility compare the pre and post war era. The three-year natural disaster and Great Cultural Revolution form the unique developing experience of China, which encourage us to examine the post reform and opening up era of China.

1.4 Research Questions

This study addresses the following research questions in analyzing the real output fluctuation in China:

- First, we examine the evidence and the nature of the decline in output volatility in China
- Second, is there one or more structural breaks in the Chinese real GDP growth rate towards stabilization or destabilization, if yes, when did these happen?
- Third, what are the reasons for the changes in patterns of output volatility in China?

This study begins with an examination on the decline in output volatility in China and shows the decline of standard deviation of quarterly output growth rate over past years. By using the CUSUM squares test and Quandt-Andrews breakpoint test to identify unknown structure breaks, this study identifies two structural breaks: 1994:1 towards destabilization and 1998:1 towards stabilization. We then examine the stochastic process for GDP and our results show this decrease in volatility came from smaller external shocks, rather than from a decrease in the persistence effects of these shocks on output. Following this, we reached two conclusions. First, there is a strong relationship between movements in output volatility and the movements in inflation volatility. Both output and inflation volatilities increased significantly during the third and fourth quarter in 1994 and then dropped sharply after 1996, which followed a similar path over the period. Second, using the standard decomposition of GDP, the

decrease in output volatility can be traced to a number of proximate causes: decrease in the volatility of consumption, investment, and net export. In addition, we go one step further in disaggregating consumption and investment components to show that rural consumption expenditure and residential investment contributed the most to the decline in output volatility.

1.5 Outline of the Thesis

Chapter One outlines the general description of the study, including the background, research problems and questions, and the purpose of the research. Chapter Two provides an overview of the Great Moderation including the causes of the Great Moderation. Past studies concerning inflation and output volatilities will also be discussed in the chapter. Chapter Three describes the theoretical and empirical framework used in this research. It will also discuss the sampling procedure, data collection method. Chapter Four presents the findings and interpretations of the empirical models. Chapter Five concludes the research, summarizes the findings and provides recommendations for future research.

Chapter 2

LITERATURE REVIEW

2.1 The Natures of the Great Moderation

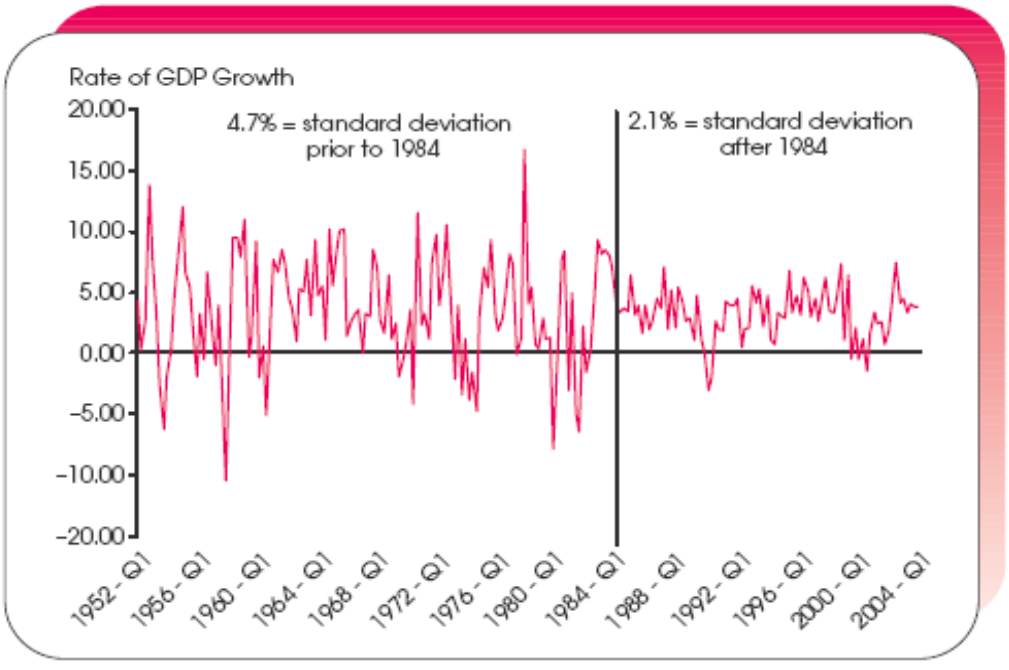
2.1.1 Volatility Decline in the United States

Macroeconomic activity in the United States has been significantly less volatile since the early 1980s. For example, Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) studied the growing stability of the U.S. economy, and independently conclude that there was a sharp reduction in the variance of U.S real GDP growth rate since the first quarter of 1984. Blanchard and Simon (2001) documented that the standard deviation of the U.S. quarterly growth in real output has declined by half since the mid-1980s, while the standard deviation of the U.S. quarterly inflation has declined by about two thirds. Stock and Watson (2002) provided a comprehensive characterization of the decline in volatility in 22 major U.S. macroeconomic time series. They found all series are less volatile in the 1990s than over the full sample period (1960-2001), and all but one series (consumption of nondurables) were less volatile in the 1990s than in the 1980s. In addition, their result showed the reduced volatility extended to several sectors of the economy, particularly durable goods, residential investment, and output of structures.

Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Stock and Watson (2002) suggested that the decrease in volatility of the U.S. economy occurred either

suddenly or due to a sharp break in the mid-1980s. Others such as Blanchard and Simon (2001) argued that the volatility probably moderated more gradually over several years. These findings are consistent with the decline in the U.S. macroeconomic volatility from the early 1980s to the middle of 1980s. The data in Figure 2.1 shows the growth rate of U.S. real GDP from 1952 to 2004. The figure explicitly shows that before 1984, the standard deviation of the U.S. quarterly real GDP growth rate was 4.7%, but dropped to 2.1% after 1984, a decline of more than half.

Figure 2.1 Standard Deviation of US Real GDP Growth Rate



Source: Michelle T. Armesto, and Jeremy M. Piger. *(*2005). "International perspectives on the "Great Moderation"," *International Economic Trends*, Federal Reserve Bank of St. Louis.

According to Stock and Watson (2002), the standard deviation of the four-quarters of the GDP growth rate was around 2.3 per cent during the whole sample period (1960-2001) (see Table 2.1). In the 1960s, the standard deviation of the GDP growth rate was 2.0 per cent, but it increased to 2.7 per cent in the 1970s and 2.6 per cent in the 1980s. During the 1990s, the standard deviation of the GDP growth rate was only 1.5 per cent.

Table 2.1 Summary Statistics of U.S. Real GDP (1960-2001)

Sample period	Mean (%)	Standard deviation (%)
1960-2001	3.3	2.3
1960-1969	4.3	2.0
1970-1979	3.2	2.7
1980-1989	2.9	2.6
1990-2001	3.0	1.5

Notes: Summary statistics are shown for $100 \times \ln (GDP_t/GDP_{t-4})$, where GDP_t is the quarterly value of real GDP.
Source: Stock, James H., and Mark W. Watson 2002. "Has the Business Cycle Changed and Why?" National Bureau of Economic Research, *Macroeconomics Annual 2002*.

2.1.2 Volatility Decline in other G-7 Countries and Australia

The Great Moderation in the business cycles occurred not only in the U.S., but also in other G-7 countries and Australia. Blanchard and Simon (2001), Summers (2005), and Stock and Watson (2003) document similar declines in the volatility of output in these countries, but the timing and nature of the decline differ across countries (see Table 2.2).

Table 2.2 Major Economies-Magnitude and Estimated Dates of GDP Volatility Reduction, 1960-2004

	Ratio of Low to High Volatility (Pct.)	Date of Switch to Low Volatility
Australia	**45.8**	**1984 Q3**
Canada	**58.0**	**1988 Q1**
France	**54.2**	**1976 Q3**
Germany	**48.3**	**1971 Q3**
Italy	**50.8**	**1980 Q2**
Japan	**62.9**	**1975 Q2**
United Kingdom	**51.5**	**1982 Q2**
United States	**50.8**	**1984 Q4**

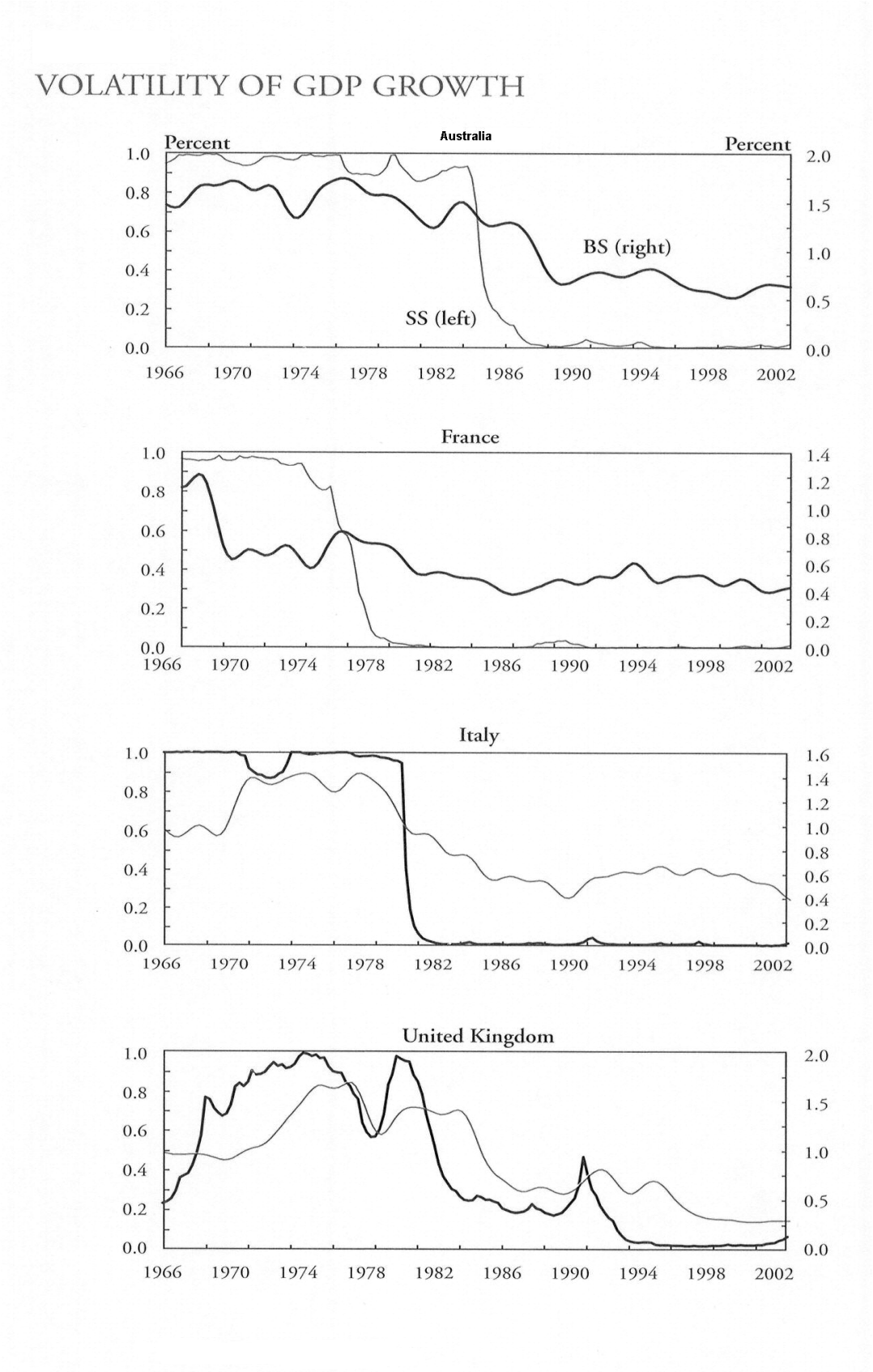
Notes: In the case of multiple switching dates, the reported dates are those which most likely coincides with the Great Moderation.

Source: Peter M. Summers, "What Caused the Great Moderation? Some Cross-Country Evidence," Federal Reserve Bank of Kansas City *Economic Review,* Third Quarter 2005.

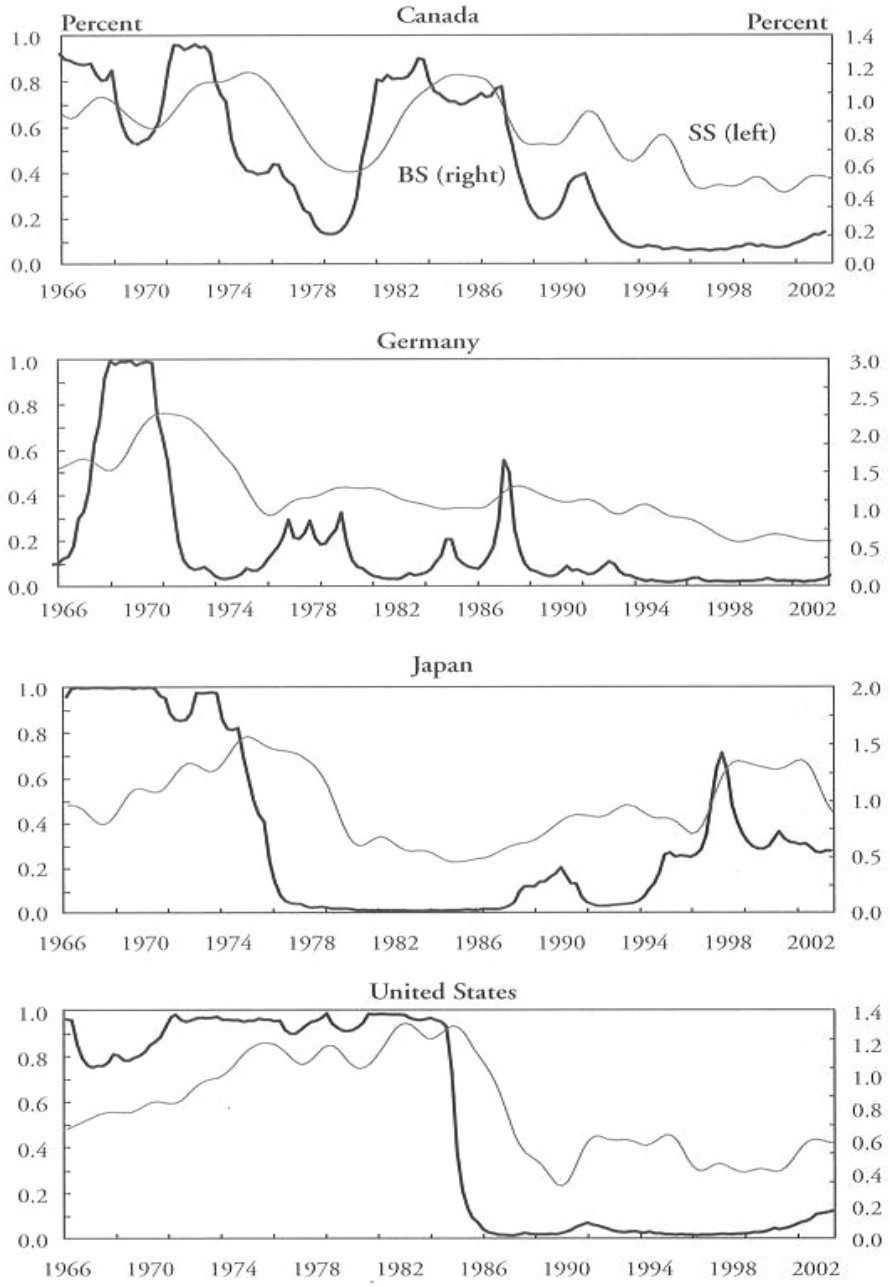
Among the G7 countries, the earliest reductions in volatility took place in Germany, and followed by Italy, France, and the United Kingdom. The latest occurred were Canada and the U.S. The volatility reduction in Australia happened almost the same time as the U.S. in the mid-1980s. Furthermore, the decline in volatility occurred much rapidly in Australia, France, Italy, and the U.S. On the contrary, the volatility moderated more gradually, increasing twice from high to low over the sample period in Canada, Germany, Japan, and the U.K. (see Figure 2.2).

However, the volatility pattern in Japan clearly differs from the other G-7 countries. For example, the standard deviation of the Japanese GDP growth rate decreased during the 1970s, but the volatility increased from the 1990s to the present. According to Yu (2006), the low output volatility in Japan from 1970s to 1990s was attributed to inflation targeting. The passive monetary policy caused by the asset bubble bursts accounts for most of the increased output volatility in the 1990s. In addition, the zero nominal interest rates in Japan have constrained monetary policy responses to increase in inflation rate, which is another explanation for high volatility in Japan during the 1990s.

Figure 2.2 Volatility of GDP Growth: G-7 Countries and Australia (1966-2002)



VOLATILITY OF GDP GROWTH (continued)

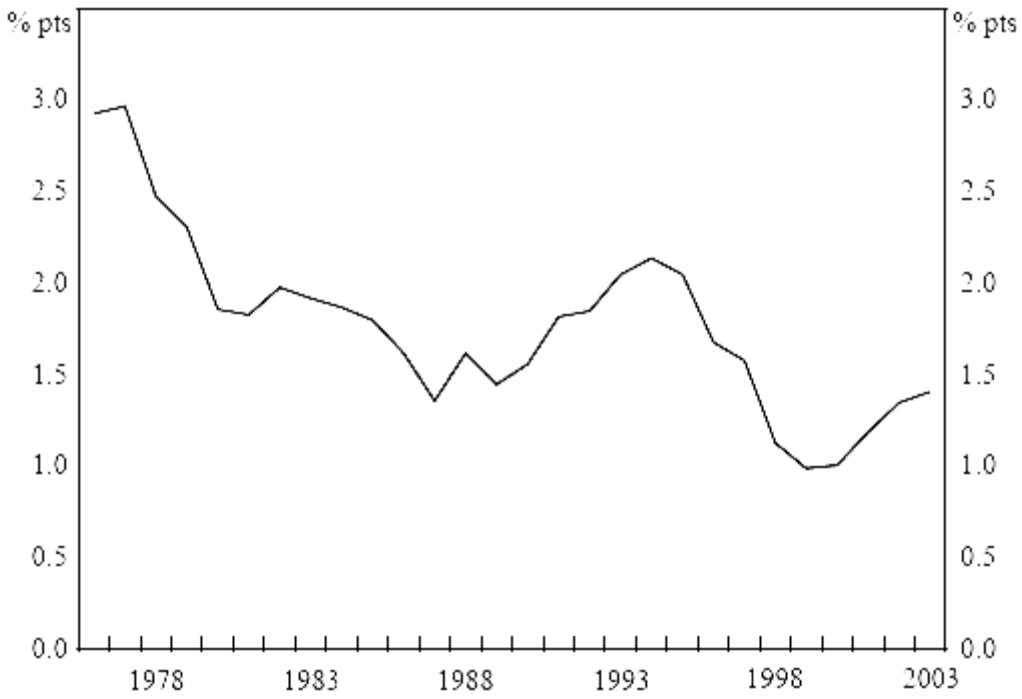


Source: Summers, Peter M., "What Caused the Great Moderation? Some Cross-Country Evidence," Federal Reserve Bank of Kansas City *Economic Review,* Third Quarter 2005.

Note: left axis measures SS; right axis measures BS. SS is the probability that GDP volatility is high. BS is the standard deviation of GDP growth prior 20 quarters.

Kent, Smith, and Holloway's (2005) study showed there has been a significant decline in volatility of the real GDP growth rate in the 20 selected OECD countries[2]. The data in Figure 2.3 shows on average, the standard deviation of the GDP growth rate of the OECD countries has dropped over one percentage point since the 1970s. They concluded that less product market regulation and stricter monetary policy were the most likely explanations for the decline in output volatility.

Figure 2.3 Average Output Volatility for 20 Selected OECD Countries' Standard Deviation Annual GDP Growth (1978-2003)



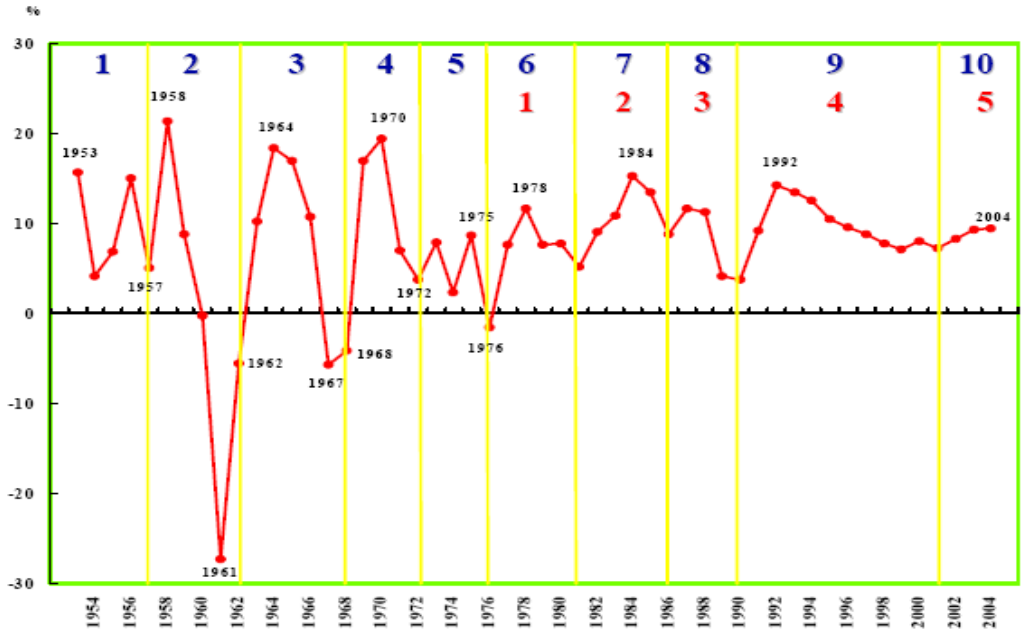
Source: ABS; Thomson Financial; World Bank World Development Indicators

[2] The OECD countries include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

2.1.3 Volatility Decline in China

According to Liu (2004), China has experienced ten businesses cyclical fluctuations since the founding of the People's Republic of China (see Figure 2.4).

Figure 2.4 Cyclical Fluctuation of China's Economic Growth (1953-2004)



Source: Shucheng Liu, "The Cycles of the Chinese Economy and Macroeconomic Regulation," Chinese Academy of Social Sciences, 2004

The economic growth is characterized by erratic ups and downs that lasted for several decades. Before 1976, there were three severe GDP growth fluctuations in China. In 1958, the GDP growth rate was 21.3 percentage points, 18.3 percentage points in 1964, and 19.4 percentage points in 1970, but dropped dramatically to negative 28 percentage points, negative 5 percentage points and 2 percentage points respectively. Noticeably, in each period of fluctuation, the highest GDP growth rate was around 20 percentage points, while the lowest point increased from negative to positive percentage points.

From 1977 to the present, China has gone through five economic cyclical changes and entered into a long period of expansion. Since the introduction of reforms and opening to the Western world initiated by the late Deng Xiao-ping in 1978, China's post-Maoist economy has grown rapidly and because of its size, dynamic growth, and continuing reform policies, China has clearly become a major powerhouse in the world economy. The ninth economic cycle started from the beginning of 1991 to the fourth quarter of 1999. In 1990, the GDP growth rate was 3.8 per cent, which is the lowest since China's reform and policy restructuring in the 1980s. In 1991, China's output growth rate was 9.2 per cent and reached a peak of 14.2 per cent in 1992. In order to prevent overheating of the economy in 1993, the central government adopted contractionary macroeconomic regulations. Therefore, between 1993 and 1996, the GDP growth rate decreased gradually to 9.6 per cent and achieved an economic soft-landing successfully.

From 1997 to 2000, China's GDP growth rate dropped further due to the 1997 Asian financial crisis. In 1999, the GDP growth rate declined to 7.1 percent ending with a slight deflation. The central government adjusted its macroeconomic regulations in 1998, focusing on expansionary fiscal policy and prudent monetary policy to defend against the negative effects of the Asian financial crisis.

In 2000, the GDP growth rate rebounded to 8 per cent. China's GDP growth rate dropped slightly to 6.7 per cent in the second quarter of 2003, which was affected by

SARS epidemic. However, the GDP growth rates in the third and fourth quarters continued to increase over 9 per cent in the same year. The excessive rapid economic growth has directly caused a supply crisis in the coal, power, fuel and transportation sectors. As a result, this supply shock led to the shortage of critical raw materials, such as steel and cement and increases price inflationary pressures. To ensure a stable, continuous, and healthy economic growth, the central government in 2003 adopted another tight macroeconomic policy to prevent severe economic fluctuations and inflation. As a result, the GDP growth rate increased gradually from 2004 to 2006 just over 10 per cent reaching 11.4 per cent in 2007.

In summary, there are five “economic characteristics” of China’s post reform economic fluctuations: first, the magnitude of the fluctuations reduced dramatically; second, the altitude or the height of the fluctuations decreased; third, the depth of the fluctuations altered from negative to positive; fourth, the average growth rate has increased; and fifth, the length of expansion period was extended. The era of erratic ups and downs has ended; stability and sustainability are the new characteristics of China’s current economic growth. The decline in the volatility of the GDP growth rate indicates that China's economy has become healthier and more stable with increasing anti-risk capability.

2.2 Causes of the Great Moderation

2.2.1 Changes in the Output Process

An interesting question remains as to whether this decrease in output volatility reflects a lower standard deviation of output shocks, or a change in the dynamic process through which these shocks affect output, or both.

Blanchard and Simon (2001) modeled output growth as an autoregressive (AR) process, decomposing output volatility into two components: one component representing the volatility of external shocks, such as changes in oil prices, monetary policy, and technology shocks, and the other represents the internal dynamics such as changes in inventory behavior. By estimating the autoregression model, Blanchard and Simon (2001) showed that this decrease in volatility can be traced primarily to a decrease in the standard deviation of output shocks, rather than to a change in the dynamics of output.

Rafferty (2003) adopted the same method and re-examined the issue using data for twenty manufacturing industries defined by two-digit Standard Industrial Classification (SIC) codes. Rafferty decomposed output volatility into two components. The first component is directly related to output shocks and the second represents the dynamic response of each industry to shocks. Rafferty (2003) pointed out the decrease in output volatility is not only a decrease in the volatility of shocks, but also a decrease in the persistence of shocks.

2.2.2 Better Monetary Policy

In the past few decades, many countries have adopted stricter monetary policy regimes regarding inflation and the central banks have become more independent, which lead to the widespread decline in inflation volatility. Blanchard and Simon (2001) showed that output and inflation volatilities have had a strong tendency to move together, both in the U.S. and other industrial countries. Since the mid-1980s, the standard deviation of the U.S. quarterly growth in real output has declined by half, while the standard deviation of quarterly inflation has declined by about two thirds.

Monetary policy did not directly lead to better output stabilization, but it has been important in reducing output volatility indirectly in two ways. First, a smarter countercyclical monetary policy results a greater moderation in output; second, better monetary policy leads to lower and more stable inflation. Therefore, better monetary policy provides a more favorable economic environment to achieve more stable output growth.

In the U.S., both output and inflation volatilities increased significantly during the pre-Volker period (1960 to mid-1979) and both dropped sharply after 1984 during the Greenspan era. Judd and Rudebusch (1998), Taylor (1999), and Clarida, Gali, and Gertler (2000) used U.S. data and showed large increases in the inflation response in Taylor-Type monetary policy rules for the short-term interest rate (see Table 2.3).

Table 2.3 Estimates of Historical Taylor Rule Coefficients for the US

	Pre-1979		1979-1987		Post-1987	
Source	g_π	g_y	g_π	g_y	g_π	g_y
Judd and Rudebusch (1998)	0.85	0.88	1.69	0.36	1.57	0.98
Taylor (1999)	0.81	0.25			1.53	0.77
Clarida, Gali, Gertler (2000)	0.83	0.27	2.15	0.93	2.15	0.93

Source: Judd and Rudebusch (1998), Taylor (1999), and Clarida, Gali, and Gertler (2000).

Taylor-Type rules relate changes in the short term interest rate R_t (in the U.S. it is the Fed Fund rate) to deviations of inflation from target and the size of the output gap:

$$R_t = r^* + \pi^* + g_\pi(\pi_t - \pi^*) + g_y(y_t - y^p_t)$$

Where r^* is the long-term equilibrium real interest rate, π_t is the average rate of inflation over four quarters, π^* is the target rate of inflation, y_t is the logarithm of GDP in quarter t, y^p_t is the logarithm of potential GDP, and $y_t - y^p_t$ is the output gap. g_π and g_y are Taylor-type coefficients that govern the responses of interest rates to deviations of inflation from target to deviations of output gap. Taylor (1993) suggested coefficients g_π=1.5 and g_y=0.5, so that the central bank responds to a one percentage point increase in the rate of inflation sustained for four quarters by increasing the short rate by 150 basis points.

As shown in Table 2.3, before 1979, the Taylor-rule coefficient on inflation (g_π) was less than one, which means a small increase in the short term rate in respond to an

increase in the rate of inflation can potentially lead to further increases in expected inflation. However, after 1979, the inflation coefficient (g_π) was greater than one, which indicates the Fed has become more responsive to inflation and output volatility and reduced both actual and expected inflation.

Taylor (2000) argued that final sales and GDP experienced approximately the same magnitude decline in volatility, which suggests something other than inventory behavior explains the "Great Moderation". His study argued that the shift in monetary policy towards controlling inflation has prevented inflation from getting out of control. Therefore, the Fed has not sacrificed the expansion to fight inflation. This view suggests a very strong link between inflation and output volatility with monetary policy driving both phenomena.

In 1990s, China experienced a high inflationary period, especially the third and fourth quarter of 1994 where the inflation rate reached its highest, 24 percent. In order to prevent overheating of the economy, the central government adopted contractionary macroeconomic regulations to get inflation under control. Both output and inflation volatilities increased significantly during the third and fourth quarter in 1994 and both dropped sharply after 1996, which followed a similar path over the period. Therefore, the sharp decline in output volatility in the 1990s appears to be associated with a sharp decline in inflation volatility at that time.

2.2.3 Disaggregate Look

Burns (1960) argued that a trend decline in output volatility was indeed underway. Composition effects including the shift from manufacturing toward services, the increase in the income tax, the increasing ability of consumers to smooth consumption in the face of variations in income, improvements in capital markets, and stronger automatic stabilizers have improved the ability of the country to manage demand shocks, which continue to lead to more economic stability. Indeed, there has been a sharp decline in output volatility in most of the industrialized nations over the past few decades. Burns was correct about the trend.

McConnell, Mosser, and Perez-Quiros (1999) examined changes in the growth rate volatility in the major components of aggregate GDP, which include consumer spending, residential and business investment, government purchases, and international trade since the early 1980s. McConnell et al. showed that the growth rates of the components became less volatile after 1983. For example, residential investment, exports, and imports experienced the largest absolute declines in growth volatility, while the Federal government purchases and consumer spending experienced the smallest reduction in volatility. By calculating the growth contributions[3] of GDP components, the authors found inventory investment and consumer spending were particularly important in accounting for the overall decline in volatility.

[3] The growth contribution equals to real growth rate of the component multiplied by the component's share of total GDP. It takes into account the size of each component relative to GDP and provides a convenient measure for adding up the components of output growth rates.

In the U.S., regulatory and structural changes in the 1980s has contributed to the sector's stability, largely by enabling banks and other financial institutions to stabilize the supply of funds for housing investment. The development of the market for mortgage-backed securities and the increased use of interest rate swaps permitted banks and other financial institutions to better hedge their exposure to changes in interest rates. Therefore, lower interest rate risk allowed these institutions to offer a more stable supply of funds for housing investment. The gradual breakdown of trade barrier around the world over the past twenty years is one possible explanation for the decrease in trade volatility. In addition, changes in the composition of trade also helped reduced trade volatility in the U.S.

According to Blanchard and Simon's (2001) study, the decline in output volatility can be traced either to changes in the composition of output or to changes in the variances or covariances of its components in accounting terms. Blanchard and Simon looked at the level of disaggregate and use the standard GDP decomposition, which decomposed GDP into consumption, investment, government spending, net exports, and inventory investment. By calculating the rolling standard deviation of the growth rate of each component, their results showed that most of the decrease in the U.S. output volatility can be traced to a decrease in the volatility of consumption and investment. Given this result, Blanchard and Simon (2001) went one step further in disaggregating the components in order to trace the volatility of the consumption and investment components. The declines in the volatility of all three consumption

components: spending on durables, nondurables, and services are roughly the same, however, much of the trend reversal in consumption in the 1970s and the early 1980s comes from consumption of services. The two series for investment volatility exhibited quite different patterns. Nonresidential investment showed a steady decline and a limited increase in the 1970s. Residential investment volatility shows a steady increase from the 1950s to the mid-1980s and a sharp decrease thereafter, which is a plausible explanation.

The composition of output has changed significantly over time, especially shifting from manufacturing to services, but Blanchard and Simon's (2001) study showed that changes in composition have little to do with the decline in output volatility, since the effects largely cancelled each other out.

2.2.4 Other Causes

McConnell and Perez-Quiros (2000) and Kahn, McConnell, and Perez-Quiros (2002) proposed that improved inventory management techniques, such as just-in-time inventory management enable firms to better smooth production when facing unexpected swings in sales, which accounts for most of the reduction in output volatility. They found that the volatility of production in manufacturing decreased largely in the mid-1980s, but the volatility of sales did not. Furthermore, their results showed statistically significant break in output volatility, but not in sales volatility and changes in durable goods inventories were negatively correlated with final sales after

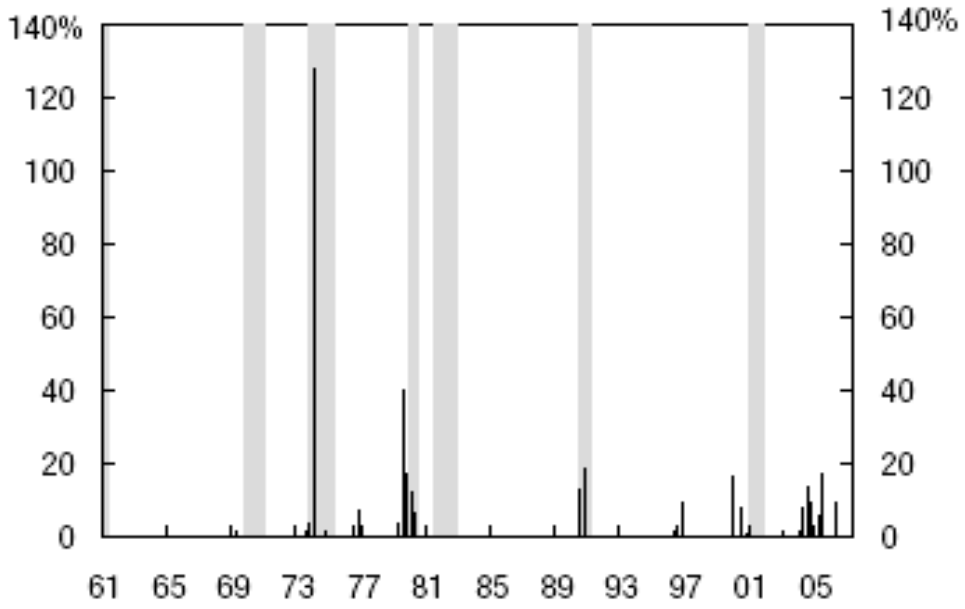
1984. They concluded that changes in inventory management methods played a central role in explaining the decline in output volatility.

Recent studies have raised concerns about the inventory management hypothesis. For example, Ahmed, Levin, and Wilson (2002), Herrera and Pesavento (2003), Kim, Nelson, and Piger (2001), and Stock and Watson (2002) found statistically significant evidence of breaks in aggregate final sales and durable and nondurable goods sales. The inventory management hypothesis also confronts other difficulties. For example, Maccini and Pagan (2003) suggested that improvement in inventory management technology will have at most a modest effect on the volatility of production, raw materials and work-in-progress inventories do not play a major role in smoothing production. Ramey and Vine (2003) suggested that in the absence of a change in inventory management methods, changes in the time series properties of sales can produce reductions in the volatility of production. Furthermore, Comin and Mulani (2004) found evidence that the time series process of firm-level sales has changed over the past twenty years, becoming more volatile. Khan and Thomas (2004) showed that just-in-time inventory management methods have little effect on output volatility. Better inventory management practices have been important at the individual firms' level, but the reduction in output volatility is widespread across sectors including production and sales. Hence, taken all together, the role of improved inventory management in explaining the great moderation in volatility is not completely convincing.

Another explanation for the great moderation is that the large adverse events affecting the economy became smaller and less frequent or due to *"good luck."* Several empirical studies support the good luck hypothesis. For example, Ahmed et al. (2002) in their study found a significant reduction in the size and frequency of shocks in the recent decades. Stock and Watson (2003) used several alternative macroeconomic models to compute the changes in the standard deviation of five different types of shocks. They concluded that improved monetary policy accounts for only 10% to 25% of the reduction in output volatility, while the variance of the economic shocks was much lower in recent decades than the variance of shocks in the early 1970s.

Internationally, most analysts focus on oil price shocks as prime example of bad luck, such as the Arab oil embargo in 1973-1974 and the Iranian Revolution in 1979-1980. The data in Figure 2.5 shows the 1973-1974 oil price shock affected the U.S. most. In the first three months of 1974, the price of imported oil increased by more than 120 percent over its previous peak. Oil price shocks have not become less frequent, but the recent oil price shocks are much smaller than those in the 1970s. Therefore, at least for the U.S. economy, the good luck hypothesis could explain the great moderation.

Figure 2.5 Oil Shocks in the United States, 1961(3) to 2006



Notes: Shaded areas represent U.S. recessions.
Sources: BLS, NBER, and *The Wall Street Journal.*

However, economists such as Ferguson (2006) challenged the findings of the good luck hypothesis because of the recent crises. Ferguson considered milder economic shocks has seemed less persuasive following the events of the late 1990s and early 2000s. From the 1997 Asian financial crisis to the September 11 terrorist attacks to the corporate governance scandals to the surge in oil prices, powerful economic shocks have adversely affected macroeconomic volatility globally. However, the economy has performed quite well over this period.

2.3 Conclusions

This chapter reviewed previous studies on decline in output volatility. It provided an overview of the natures and possible causes of the "Great Moderation" with the G7 nations' and Australian experiences. The most commonly proposed explanation for the "Great Moderation" fall into three categories: improved macroeconomic policies, economic structural change, and good luck hypothesis. In general, better monetary policy lead to better output stabilization indirectly by controlling inflation volatility. Economic structural changes have promoted stability in the growth of aggregate GDP and its individual components. Most of the decrease in the U.S. output volatility can be traced to a decrease in the volatility of consumption and investment.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the data and research methodology used in the study. Section 3.2 describes the data sources and data collection methods. Section 3.3 describes the research methodology for the natures, the timing of the structural breaks, and proximate causes of the decrease in output volatility in China.

3.2 Sample Selection and Data Collection

Secondary data is used in this study including quarterly real gross domestic product (RGDP), annually inflation rate, consumption, rural consumption expenditure, urban consumption expenditure, government consumption expenditure, investment, residential investment, nonresidential investment, government spending, and net export. Real gross domestic product was obtained from Gu (2004)[4]. The other data are obtained from China Statistical Yearbook 2008. The length of sample period is 20 years from 1987 to 2007. Pre-reform and opening up era are excluded from our sample because of the negative effects of three-year natural disaster and Great Cultural Revolution in China.

[4] Gu (2004) employed Chow-Lin procedure using GAUSS Code to interpolate China's annual real GDP to quarterly real GDP. The procedure of Chow-Lin is written by Michael Boldin. Gu generated a quarterly real GDP series from annual real GDP using the interpolating technique proposed by Chow and Lin (1971). Succinctly, this criterion generates quarterly observations from its corresponding annual figures by general least squares of related series. The two related series used are retail sales and industrial production.

The GDP deflator is used to calculate the real terms of the GDP components, which include consumption, investment, government spending, and net export. Annual data obtained from China Statistical Yearbook 2008 are converted to quarterly data by adopting low to high frequency conversion option – linear-match last method in EViews program. Real GDP are transformed to annual growth rate [$100 \times \ln(X_t/X_{t-4})$] to eliminate trends and nonstationary when employing the Quandt-Andrews Breakpoint Test.

Since our study deals with time-series data, the Cov (e_i, e_j) is assumed to be non zero, $i \neq j$. That is, any two different disturbances which correlated to each other are said to be autocorrelated. We use the Durbin-Watson statistics to test the autocorrelation problem with H_0: $\rho=0$. This study also tests whether there is a structural stability in the real GDP growth rate. We used the Dickey-Fuller test to check the stationary for real GDP growth rate.

3.3 Methodology

3.3.1 The Decline in Output Volatility

In order to investigate the dynamic measurement of the decline in output volatility in China, we calculate the rolling standard deviation of quarterly real output growth (measured in quarterly rate) since the first quarter of 1987. We use a window of twelve quarters (m=12), so that the standard deviation reported for quarter t is the estimated standard deviation over quarters t-11 (t-m+1) to t. The rolling standard

deviation (σ_t) of y_t is calculated as follows:

$$\sigma_t = \sqrt{\frac{1}{m} \sum_{i=t-m+1}^{i=t} (y_i - \overline{y_t})^2} \quad \text{.....(1)}$$

Where y_t is the rolling mean of the quarterly real output growth:

$$\overline{y_t} = \frac{1}{m} \sum_{i=t-m+1}^{i=t} y_i \text{.....(2)}$$

The length of rolling period is not fixed, and for quarterly data we can choose a window of twenty quarters or longer. According to the length of our data, we choose a three year period to measure the output volatility. By adding up all the values of standard deviation of real output growth rate will yield a curve that shows a clear trend of volatility of output growth rate over time.

3.3.2 The Timing of the Break

The CUSUM of squares test and the Quandt-Andrews Breakpoint Test are used in this study to identify unknown structural breakpoints in the sample. We estimate an Augmented Dickey-Fuller (ADF) test with a constant in the test regression and employed an automatic lag length selection using Akaike Information Criterion (AIC) to select the lag length of the autoregression model of the GDP growth rate.

To model real GDP growth rate as a first-order autoregression model, we test for structural break in the residual variance from the following specification for GDP growth rate:

$$y_t = \mu + \varphi y_{t-1} + e_t \quad \text{.....(3)}$$

Where y_t is real GDP growth rate, μ is the intercept term, φ denotes a lag polynomial, and e_t is a random error term.

Following Alexandre (2001) and McConnell and Perez-Quiros's (2000) studies, if e_t follows a normal distribution, then $\sqrt{\pi/2|\hat{e}_t|}$ is an unbiased estimator of the standard deviation of e_t. We then look for a break in an equation in the following form:

$$\sqrt{\pi/2|\hat{e}_t|} = a + v_t \quad \text{..... (4)}$$

Where a is the estimator of the standard deviation. We use the CUSUM squares test in EViews program to examine the instability period of the unconditional standard deviation over the sample period. The CUSUM squares test is based on the cumulative sum of squares of residuals, and plots the cumulative sum together with the 5% critical lines. The test finds the parameter instability if the cumulative sum goes outside the area between the two critical lines.

The Quandt-Andres test is used to identify the specific date of the structural break. The idea behind the Quandt-Andrews test is that a single Chow Breakpoint Test[5] is performed at every observation between two dates, T1 and T2. The K test statistics from the Chow tests are then summarized into one test statistic for a test against the null hypothesis of no breakpoints between T1 and T2. By default the Quandt-Andrews test tests whether there is a structural change in all of the original equation parameters. For linear specifications, EViews allows us to test whether there is a structural change in a subset of the parameters.

From each individual Chow Breakpoint Test two statistics are retained, the Likelihood Ratio *F*-statistic and the Wald *F*-statistic. The Likelihood Ratio *F*-statistic is based on the comparison of the restricted and unrestricted sums of squared residuals. The Wald *F*-statistic is computed from a standard Wald test of the restriction that the coefficients on the equation parameters are the same in all subsamples. The distribution of these test statistics is non-standard. Andrews (1993) developed their true distribution, and Hansen (1997) provided approximate asymptotic *p*-values. EViews reports the Hansen *p*-values (Object Reference from EViews6).

The distribution of these statistics becomes degenerate as T1 approaches the beginning of the equation sample, or T2 approaches the end of the equation sample. To compensate for this behavior, it is generally suggested that the ends of the

[5] The idea of the breakpoint Chow test is to fit the equation separately for each subsample and to see whether there are significant differences in the estimated equations. A significant difference indicates a structural change in the relationship.

equation sample be excluded in the testing procedure. A standard level for this "trimming" is 15%, where we exclude the first and last 7.5% of the observations. We are going to use the trimming at 15% by default. Andrews (1993) showed the asymptotic properties of the statistic as follows:

$$\sup_{T1 \le T \le T2} F_n = \sup F_n(T) \quad \text{.....(5)}$$

And he reports the asymptotic critical values. In the sub-Wald test, the T that maximizes $F_n(T)$ will be the estimated date of the break point.

3.3.3 Changes in the Output Process

In order to examine why China's real output volatility has declined, we looked at the natural process generating output movements over time and how it has changed. Is the lower volatility of real output because of a lower standard deviation of output shocks, or a change in the dynamic process through which these shocks affect output, or both? Blanchard and Simon's (2001) model output growth rate as an autoregressive (AR) process is given by:

$$(\Delta y_t - g) = a(L)(\Delta y_{t-1} - g) + e_t \quad \text{.....(6)}$$

Where y_t denotes the logarithm of output in quarter t. Δ denotes a first difference, g is the underlying growth rate of output, e_t is a white-noise shock with standard deviation σ_e, and $a(L)$ is a lag polynomial.

Then the standard deviation of output σ_y depends on the standard deviation of white-noise shock σ_e and the lag polynomial $a(L)$. Following Blanchard and Simon (2001) and Rafferty (2003), this study assumes output growth rate follows an AR(1) process:

$$(\Delta y_t - g) = a(\Delta y_{t-1} - g) + e_t,\ e_t \sim N(0, \sigma_e^2) \quad \text{.....(7)}$$

which can be re-written as:

$$\Delta y_t = (1-g)a + a\Delta y_{t-1} + e_t \quad \text{.....(8)}$$

The standard deviation of output $\sigma_y = \sigma_e / \sqrt{1-a^2}$, which is completely determined by the AR(1) coefficient a: the higher the absolute value of the AR(1) coefficient a, the higher the standard deviation of output; the lower the absolute value of the AR(1) coefficient a, the lower the standard deviation of output. This means that the volatility of output can be decomposed into two components: first, the volatility of shocks (σ_t^e) represents volatility driven by external shocks, which might be changes in monetary policy, technology shocks, oil prices etc; second, the persistence of output shocks (a_t^2) that driven by internal factors such as changes in inventory behavior (Rafferty, 2003).

We estimated Equation (8) over a rolling sample from 1987:1 with a window of twelve quarters. To interpret the changes in the process, we assumed the process to be first-order autoregressive AR(1). This may not fully capture the dynamics of output growth, but all of our conclusions extend to higher-order AR processes. We obtained three figures from this estimation: AR(1) coefficient a, estimated average GDP growth rate g, and the standard deviation of regression residuals σ_e.

3.3.4 Reasons for the Changes in the Patterns of Output Volatility

3.3.4.1 Output Volatility and Inflation

In order to determine the cause of the decline in the output volatility, we first test the correlation between the output volatility and inflation. Blanchard and Simon (2001) showed that output and inflation volatilities have had a strong tendency to move together, both in the U.S. and other industrial countries. Monetary policy leads to better output stabilization indirectly by achieving lower and more stable inflation.

In China, both output and inflation volatilities increased significantly during the third and fourth quarter of 1994 and both dropped sharply after 1996, which followed a similar path over the period. Therefore, the sharp decline in output volatility in the 1990s appears to be associated with a sharp decline in inflation volatility at that time. We tested the relationship between inflation (rolling mean) and output growth volatility (rolling standard deviations), and inflation volatility and output growth volatility to determine if the relationships tend to move together. The rolling mean of the inflation rate was calculated as follows:

$$\overline{X_t} = \frac{1}{m} \sum_{i=t-m+1}^{i=t} x_i \quad \cdots\cdots(9)$$

Where $\overline{X_t}$ is the rolling mean of the inflation rate, m is the length of rolling window. We used a window of twelve quarters (m=12), so that the standard deviation reported for quarter t is the estimated standard deviation over quarters t-11 (t-m+1) to t.

3.3.4.2 Disaggregated Look - Volatility of GDP Components

The decline in the inflation volatility and the steady monetary policy help to reduce the output volatility, but this is inadequate because output is an aggregate variable. To get a better understanding of the decrease in output volatility trend, we employed the standard decomposition of GDP by types of purchase, such as consumption, investment, government spending, and net exports as follows:

$$Y=C+I+G+(X-M) \qquad (10)$$

Let each of GDP components denoted by X_i, and Equation (10) can be represented in a reduced form as follows:

$$Y_t = \sum_i X_{it} \qquad (11)$$

For each of the X's component, we considered two measures of volatility. The first is similar to the real GDP discussed previously, where the rolling standard deviation ($\sigma x i_t^2$) of X_{it}'s growth rate (g_{it}) is given as follows:

$$g_{it} = (X_{it} - X_{it-4}) / X_{it-4} \qquad (12)$$

The second measures of the volatility called the "growth contribution", which adjusts for the share of the GDP components. The growth contribution of each component to the real GDP growth rate is denoted by d_{it}, and is defined as : $d_{it} = \Delta X_{it} / Y_{t-4}$, and can be rewritten as follows:

$$(\Delta X_{it} / X_{it-4})(X_{it-4} / Y_{t-4}) \ldots\ldots (13)$$

Therefore, if the share of component X_i is stable at high frequency, the standard deviation will be the same as the standard deviation of that components growth rate times the share of the GDP components (Blanchard and Simon, 2001). The volatility is once again measured by rolling standard deviation.

Chapter 4

DISCUSSION OF EMPIRICAL FINDINGS AND RESULTS

4.1 Introduction

This chapter presents the results and analysis of the findings. Section 4.2 presents the evidence and the nature of the decline in output volatility in China. Section 4.3 examines the timing of the structural breaks in the Chinese real GDP growth rate towards stabilization or destabilization. Section 4.4 examines the relative important of external shocks and the internal dynamics of output process. The reasons for the changes in patterns of output volatility in China are discussed in Section 4.5. Section 4.6 summarizes the findings of this study.

4.2 Measures of Reduced Output Volatility

The simplest way to examine the decline in business cycle volatility over the post-economic reform and opening up policy era in China is to study the plot of Figure 4.1 (see Appendix 1). Figure 4.1 shows four-quarter growth rate of real GDP over the 84 quarters between 1987:Q1 and 2007:Q4. In Figure 4.1, the horizontal line represents the mean growth rate of real GDP over this period, which is 9.49 per cent per annum.

As shown in Figure 4.1, the four-quarter percentage changes behave differently before and after 1999. For example, prior to 1999, the pattern is characterized by erratic ups

and downs, while after 1999 the fluctuations are much moderate. The pre-1999 fluctuations are equally volatile above and below the mean of 9.49 per cent per year. In contrast, there is nothing like the magnitude of volatility after 1999. The four-quarter growth rate of the real GDP increased gradually from approximately 8 per cent to 12 per cent between 1999 and 2007.

As summarized in Table 4.1, the standard deviation of GDP growth rate was approximately 3.96 percentage points from 1987 to 1998. However, during the post-1999 period, the standard deviation of four-quarter GDP growth rate was only 1.48 percentage points. The moderation is generally associated with reductions in the variance of GDP growth rate, not with changes in the mean of the GDP growth rate.

Figure 4.1 Four-Quarter-Ended Growth Rates of China's GDP

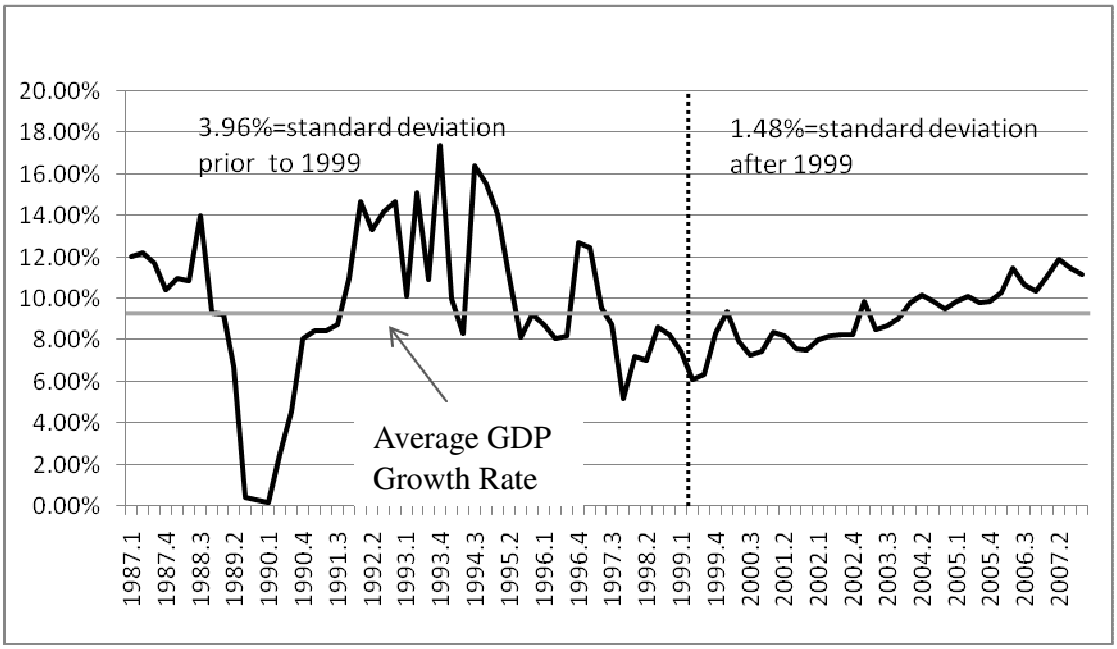


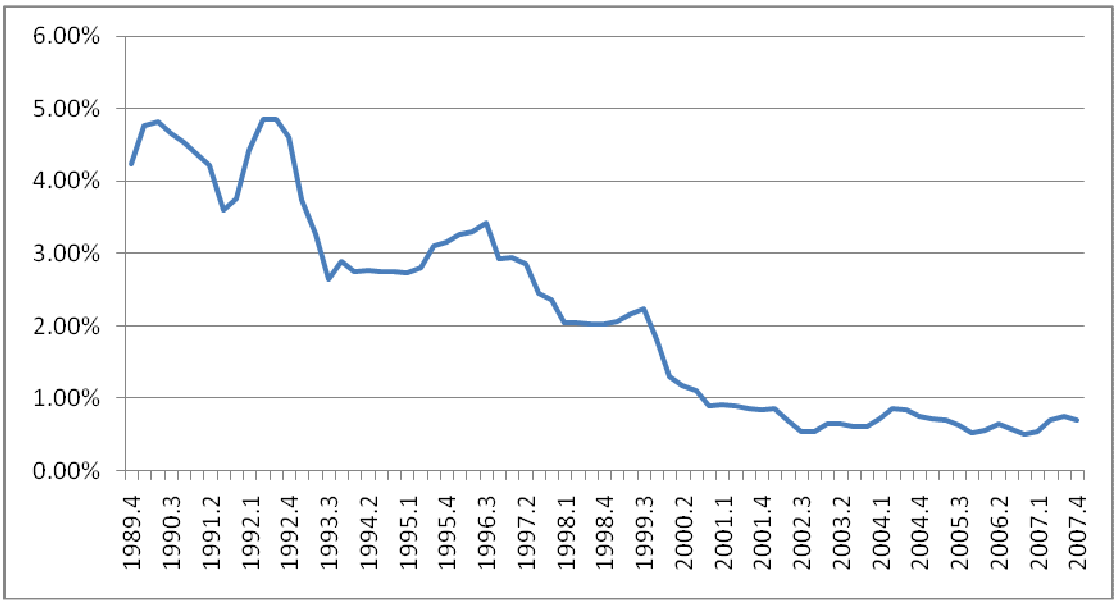
Table 4.1 Summary Statistics for Four-Quarter Growth in Real GDP, China (1987-2007)

Sample period	Mean (%)	Standard deviation (%)
1987-1998	**9.76**	**3.96**
1999-2007	**9.13**	**1.48**

Notes: Summary statistics are shown for $(GDP_t - GDP_{t-4})/GDP_{t-4}$, where GDP_t is the quarterly value of real GDP.

Figure 4.2 shows the rolling standard deviation of quarterly growth rate of real GDP since the fourth quarter of 1989, and highlights the decline in volatility evidenced in Figure 4.1. We used a window of twelve quarters, so that the standard deviation reported for quarter t is the estimated standard deviation over quarters: t-11 to t. The first available observation for GDP is 1987:1, and thus the first observation for the standard deviation of the growth rate is 1989:4. The figure shows a clear decline in the standard deviation over time, from about 4.5 per cent a quarter in the late 1980s to less than 1 per cent in the late 2000s. This decline is not continuous, however, the volatility increases from 1993 to 1996, and followed by a sharp decline in the 2000s. The mean of the standard deviations in Figure 4.2 is 3.38 percentage points for 1989:4-1998:4 and much lower 0.9 percentage points for 1999:1-2007:4.

Figure 4.2 Volatility of Output Growth (1989-2007)



Note: Estimated from Equation 1. Twelve quarter rolling standard deviation of quarterly real GDP growth rate.

4.3 Timing of the Break

In the previous section we examined the evidence and the nature of the decline in output volatility in China. The CUSUM squares test and the Quandt-Andrews breakpoint test are used in this section to identify the instability period of the output volatility, and the specific date of the decline in output volatility in China.

Before conducting the breakpoint test, we need to test for the stationary of GDP growth rate and the autocorrelation problem of the autoregression model. The data in Table 4.2 (see Appendix 2) shows the unit root (ADF) test for the real GDP growth rate and the Akaike Information Criterion (AIC), which automatically select the lag length of the autoregression model. The critical value of Augmented Dickey-Fuller statistic value is -3.0032 and the associated one-side p-value is 0.0387. We reject the

null hypothesis that the GDP growth rate (*Yt*) has a unit root at the 5% and 10% significant levels, which means the GDP growth rate is stationary I(0). EViews automatically selects the lag length of 1 (based on AIC), which means it is better to model the autoregression model of real GDP growth rate as an AR(1) model.

Table 4.2 Unit Root Test Statistic of China Real GDP Growth Rate (1987-2007)

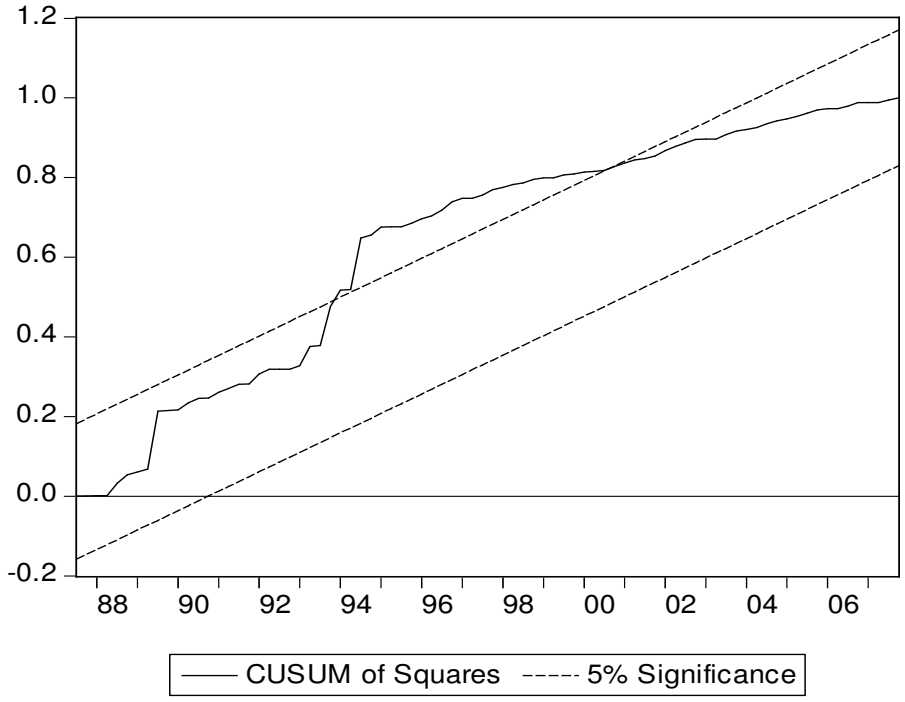
Variable	ADF Test Statistic	P-value	Result	AIC
Real GDP Growth Rate	-3.0032	0.0387	I(0)	1

Note: ADF is the augmented Dickey-Fuller test of a unit root against no unit root by Dickey Fuller (1979). P-value is from Mackinnon (1996).

We used EViews to estimate the first-order autoregression model of GDP growth rate from 1987 to 2007 (see Appendix 3). The Durbin-Watson Statistic is 2.13 and very close to 2, which means there is no autocorrelation problem.

The CUSUM squares test is used to test the instability period of the output volatility from 1987 to 2007. Figure 4.3 shows the CUSUM squares test for unconditional standard deviation in Equation 4, and plots the cumulative sum together with the 5% critical lines. Between 1994 and 2000 the cumulative sum goes outside the area between the two critical lines, which indicate instability in the residual variance. Therefore, the volatility of GDP growth rate became more volatile since the first quarter of 1994 and toward stabilization since 2000.

Figure 4.3 CUSUM of Squares Test for Unconditional Standard Deviation



We used Quandt-Andrew breakpoint test to identify the specific date of the unknown structural break. The data in Table 4.3 (see Appendix 4) reports the results of the tests for the structural break in the residual variance for China over the sample period. We found strong evidence that all three of the summary statistic measures reject the null hypothesis of no structural breaks within the 57 possible dates tested. The estimated break date is the first quarter of 1998, which is the beginning of China persistent economic constancy. One possible explanation is that in order to defend against the negative effects of the 1997 Asian financial crisis, the Chinese central government has adjusted its macroeconomic regulations that focus on expansionary fiscal policy and prudent monetary policy in 1998, which established good environment for the economic development afterward. In addition, there was a supply crisis in coal, power,

fuel and transportation sectors in 2003 because of the excessive rapid economic growth. The central government in 2003 adopted another tight macroeconomic policy to prevent severe economic fluctuations and inflation. As a result, the GDP growth rate increased gradually thereafter. These adjustments of macroeconomic policies indicate the Chinese central government has become more responsive to negative shocks and reduced both actual and expected inflation, which ensure a stable, continuous, and healthy economic growth in China.

Also, since the original equation was linear, the LR *F*-statistic is identical to the Wald *F*-statistic. To test for an unknown structural break point amongst all the original regressors we run the Quandt-Andrews test with 15% trimming. This test gives the following results:

Table 4.3 Structural Break Tests:
China Real GDP Growth Rate (1987:1-2007:4)

Specification: $y_t = \mu + \varphi y_{t-1} + e_t, e_t \sim N(0,\sigma^2_t)$			
Variable	Sup W_T test Statistic	P-value	Estimated break date
Real GDP Growth Rate	19.09	0.0003	1998:1

To get a better understanding of both trend decrease and the timing of the break, the next section examines the changes in the output process and proximate causes.

4.4 Changes in the Output Process

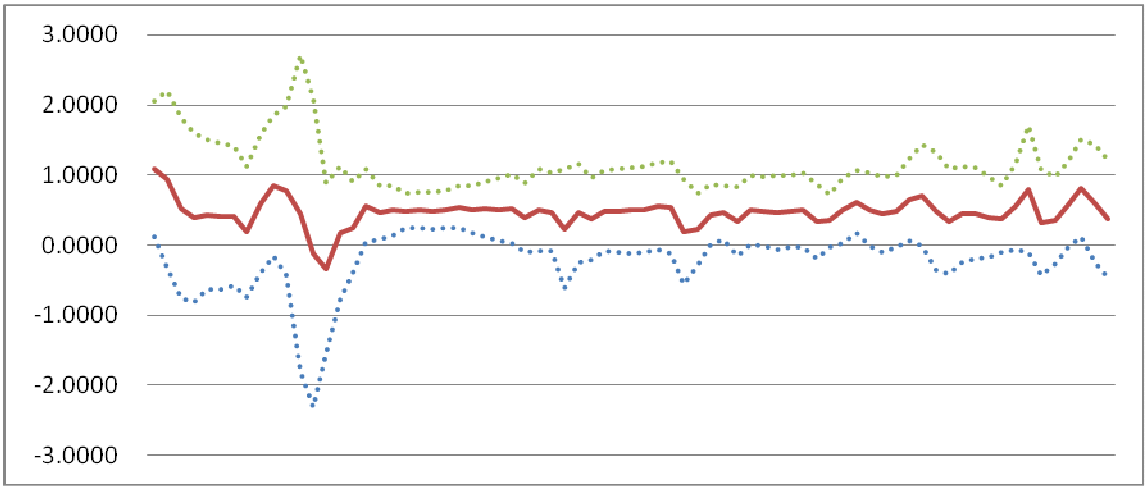
This section examines the relative importance of the external shocks and the internal dynamics of output process. We examined this issue by decomposing output volatility into a component representing the volatility of external shock and one component representing the internal dynamics.

Figure 4.4a shows the estimated AR(1) coefficient, Figure 4.4b shows the estimated mean growth rate, and Figure 4.4c the estimated standard deviation of the shock. The other two dash lines in top and middle panels show two-standard-deviation bands on each side of the estimate.

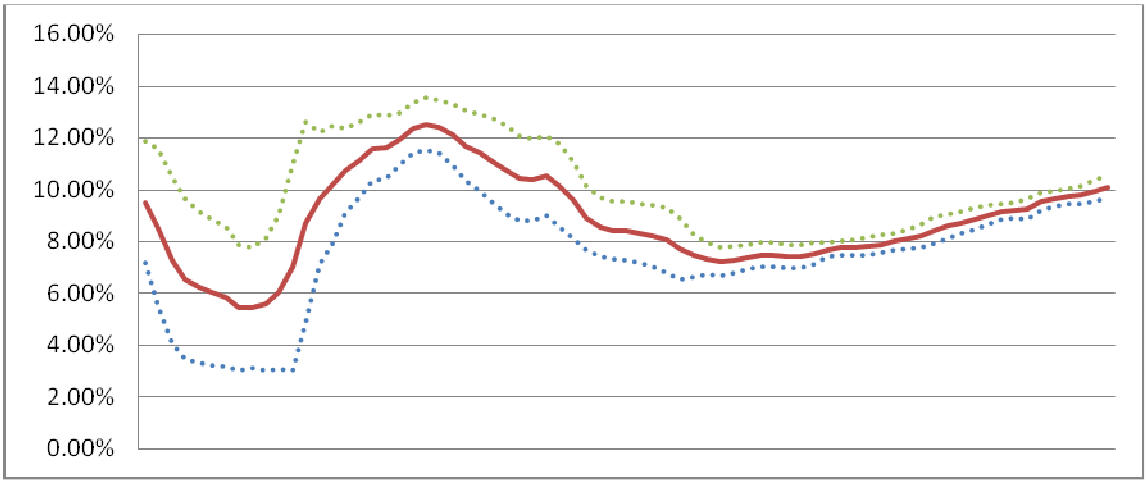
The results in Figure 4.4 (see Appendix 5) are straightforward. Neither the AR(1) coefficient nor the growth rate shows a clear movement over time. The growth rate is slightly higher in late 2000s than the rest of the sample, but the difference is not significant. The standard deviation of the regression residual decreased from about 4.5 per cent in the early 1990s to less than 1 per cent in 2000s, which shows similar time pattern as the standard deviation of output growth in Figure 4.2. Indeed, if plotted on the same graph, their profiles would be nearly identical, which is shown in Figure 4.5. Except the volatile fluctuation period from late 1993 to 1996, the patterns are roughly the same. In terms of autoregression, the variance reduction is attributable to a smaller error variance, not to changes in the autoregressive coefficients.

Figure 4.4 Time Variation of Key Parameters (1989-2007)

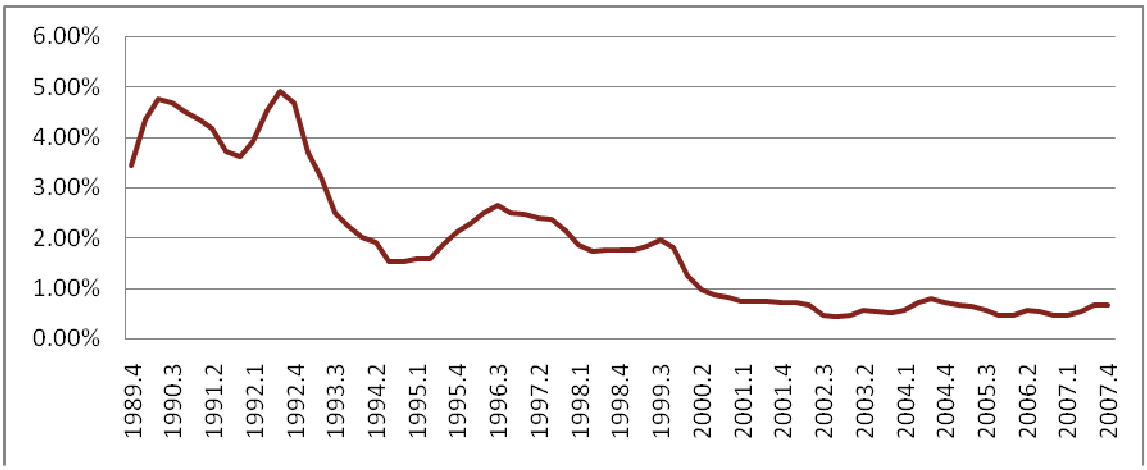
a. AR (1) Coefficient



b. Estimated Average GDP Growth Rate

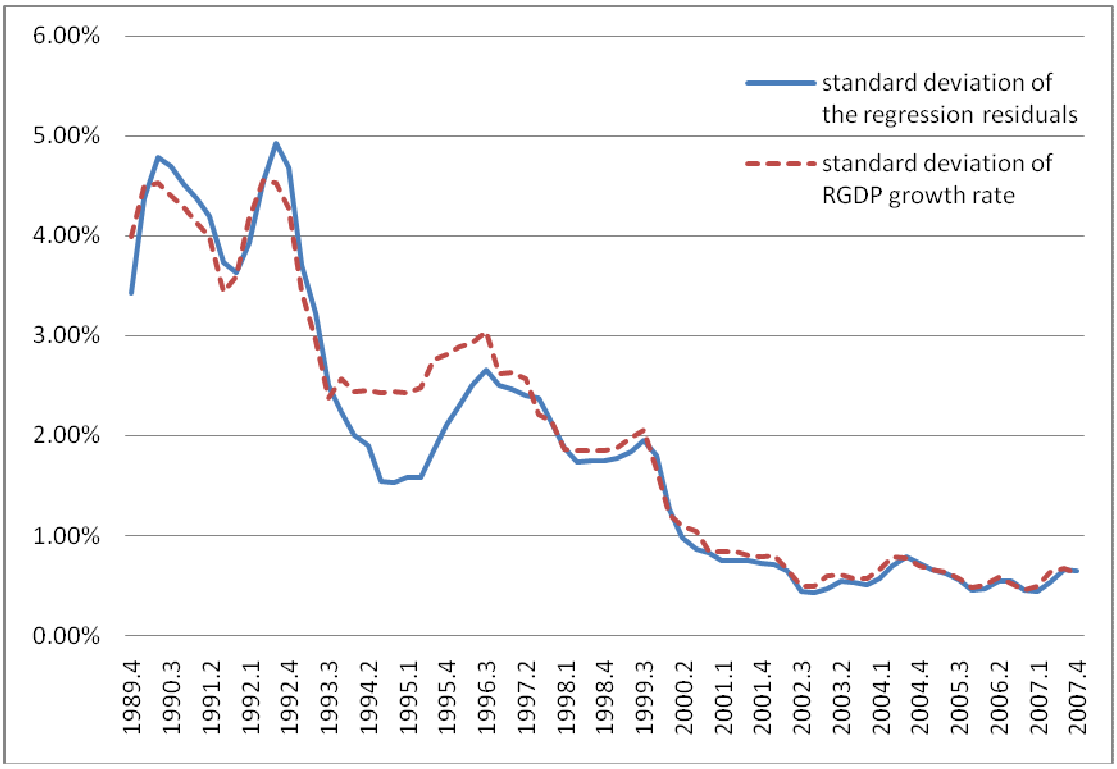


c. Standard Deviation of Regression Residuals



Note: Estimated from Equation 8. Results are for twelve-quarter rolling regressions. Two-standard-deviation bands are shown for AR (1) coefficient and average GDP growth rate.

Figure 4.5 Comparison of the Standard Deviation of Real GDP Growth Rate with the Standard Deviation of the Regression Residuals



This conclusion is consistent with the findings of Ahmed et al. (2002), Blanchard and Simon (2001), Pagan (2000), and Sensier and Dijk (2001). To conclude, the decrease in output volatility appears to come from smaller external shocks, such as changes in oil prices, monetary policy, and technology shocks, rather than from a decrease in the persistence of the effects of these shocks on output.

4.5 The Reasons for the Changes in the Patterns of Output Volatility

4.5.1 Relationship between Inflation and GDP Volatility

In the U.S., both output and inflation volatilities increased significantly during the pre-Volker period (1960 to mid-1979) and both dropped sharply after 1984 during the Greenspan era. In China, both output and inflation volatilities increased significantly during the third and fourth quarter of 1994 and both dropped sharply after 1996, which followed a similar path over the period. Therefore, the sharp decline in output volatility in the 1990s appears to be associated with a sharp decline in inflation volatility at that time.

Figure 4.6 (see Appendix 6) shows the relationship between inflation and output growth volatility. Figure 4.6a plots the output growth volatility against the twelve-quarter rolling mean of the inflation rate. Figure 4.6b plots the output volatility against inflation volatility, both constructed as twelve-quarter rolling standard deviations. All variables, including mean inflation, are measured in quarterly rates.

The temporary increase in the level of inflation from 1993 to 1996 is clearly correlated with the temporary increase in output volatility. Between 1996 and 2001, the sharp decline in the level of inflation leads to lower GDP growth rate, and output volatility decreased dramatically. As shown in Figure 4.6b, the inflation volatility changes differently before and after 1998. Prior to 1998, the inflation volatilities were between 2.5% and 6.5% interval and a saw-tooth pattern was evident. Following 1998,

the inflation volatilities drop significantly and the fluctuations are much more moderate between 0.8% and 1.2% interval. The output volatility followed a similar path over the period.

Figure 4.6a Relationship between Output Volatility and Inflation Mean (1989:4-2007:4)

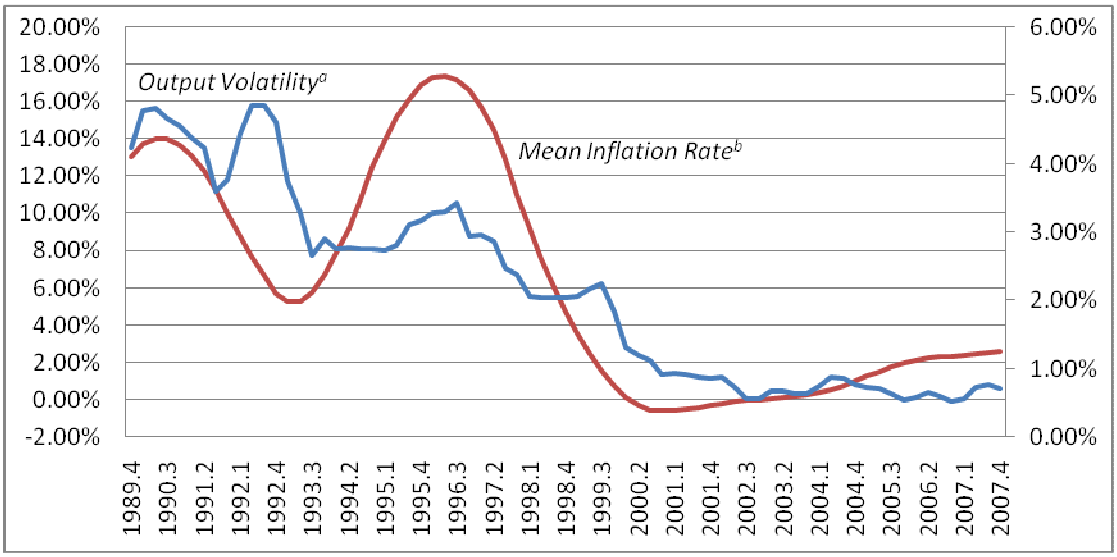
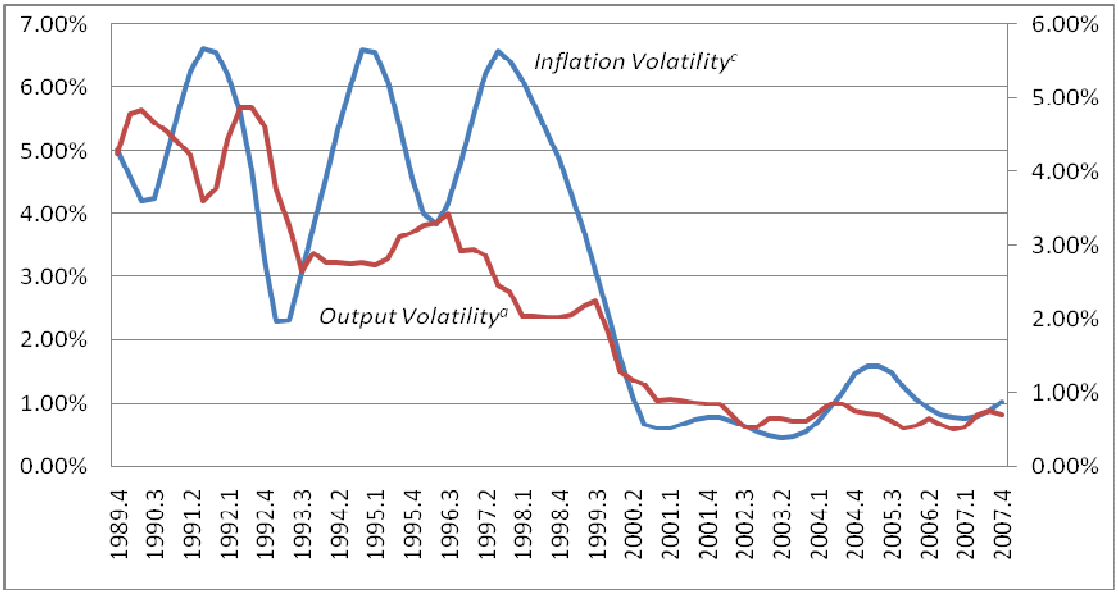


Figure 4.6b Relationship between Output Volatility and Inflation Volatility (1989:4-2007:4)



a. Twelve-quarter rolling standard deviation of quarterly real GDP growth.

b. Twelve-quarter rolling mean of the quarterly inflation rate.

c. Twelve-quarter rolling standard deviation of quarterly inflation rate.

The correlation between the level of inflation and output growth volatility is 0.778, and the correlation between inflation volatility and output growth volatility is 0.779. In short, the sharp decline in output volatility in the 1990s appears to be associated with a sharp decline in inflation volatility at that time, and they are positively related. However, output volatility seems more strongly related to the inflation volatility than to the level of inflation.

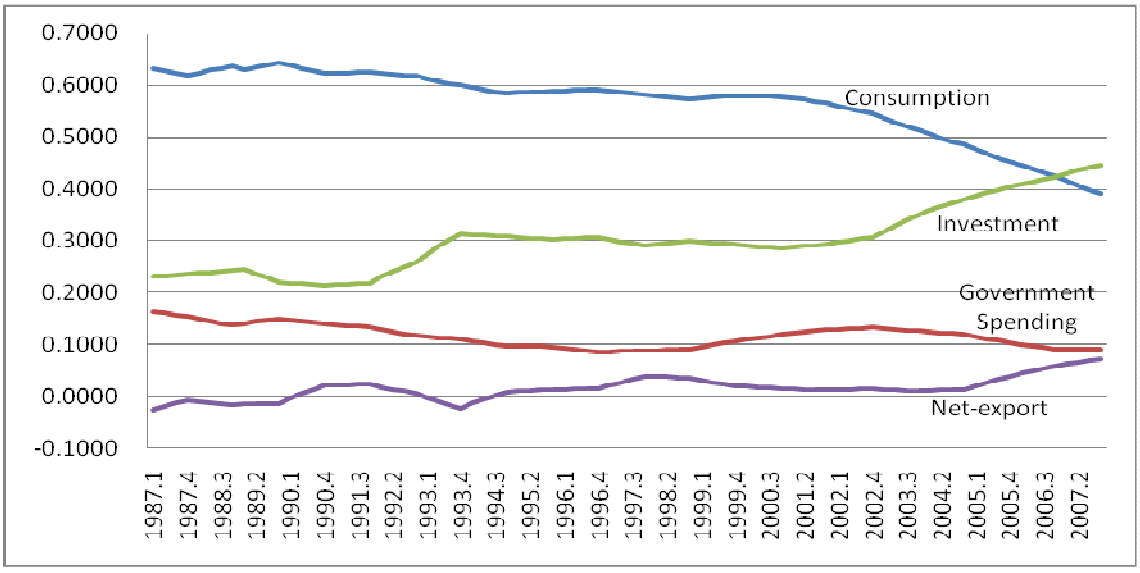
However, the correlation between output volatility and inflation does not imply the causality from inflation to output volatility. The correlation may have been due to a third factor such as supply shocks that can influence both. Blanchard and Simon (2001) considered the evidence from other G7 nations' members. Their motivation is that the different timings of disinflation across these countries can help them separate out the effects of inflation from supply shocks. They first show that these countries have also experienced a decline in output volatility, and after controlling for common time fixed effects, inflation volatility still appeared to be strongly related to output volatility. In our study, a third factor might exist that can influence both the output volatility and inflation. However, as suggested in Blanchard and Simon's (2001) study, our result is robust enough to verify the strong relationship between inflation volatility and output volatility.

4.5.2 Volatility of GDP components

The decline in the inflation volatility and the steady monetary policy help to reduce the output volatility, but this is inadequate because output is an aggregate variable. To get a better understanding of the decrease in output volatility trend, this section goes one step further and looks at the trends in the individual GDP components. We used the standard decomposition of GDP that decomposes the GDP into consumption, investment, government spending, and net export.

Figure 4.7 (see Appendix 7) shows the change of the share of GDP component from 1987 to 2007. The composition of GDP has changed substantially over the last twenty years. The two main changes include an increase in the share of investment, from 23.2 per cent of the GDP in 1987 to 44.6 per cent in 2007 and a decrease in the share of consumption, from 63.2 per cent to 39.2 per cent. In addition, the share of government spending remains unchanged, and the share of net export increased slightly.

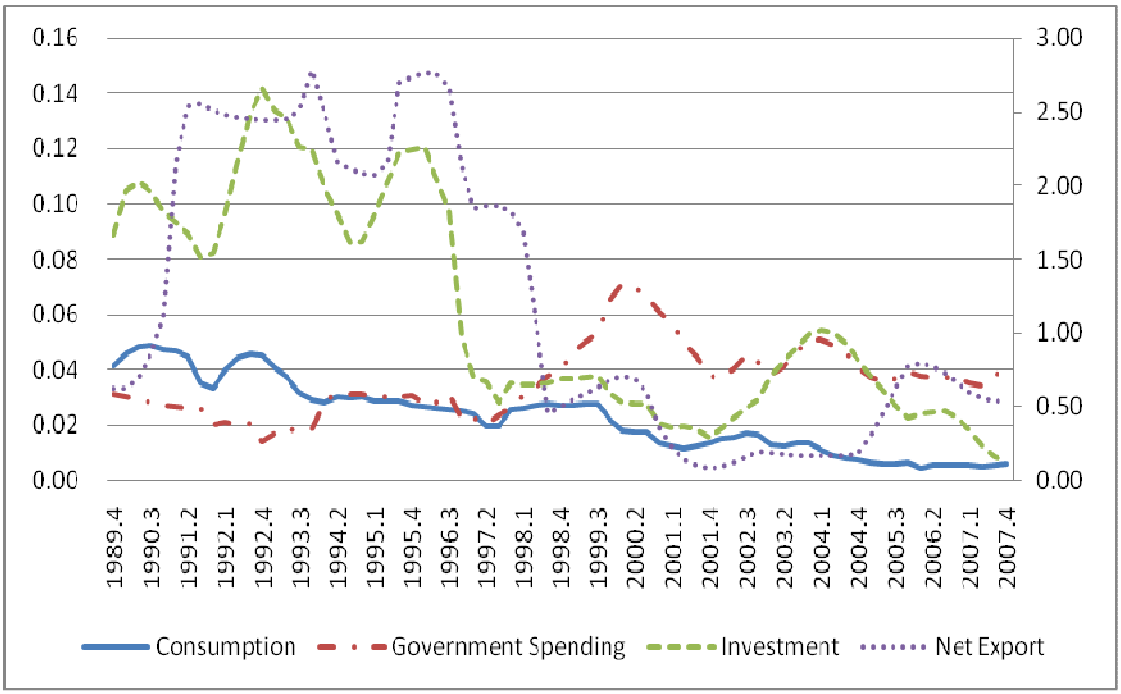
Figure 4.7 Changes of the Share of GDP Component (1987-2007)



For each of the GDP component, we considered two measures of volatility: rolling standard deviation of growth rate and rolling standard deviation of growth contribution. For both volatility measures, we used twelve quarters window to compute standard deviation.

Figure 4.8 describes the rolling standard deviation of four GDP components from 1989 to 2007. In 1990s, the volatility in investment is the highest, followed by the consumption and government spending. Although the share of net export is minor, extremely high volatility of net export cannot be neglected. Therefore, net export has certain contribution to the decline in output volatility.

Figure 4.8 Rolling Standard Deviation of GDP Components (1989-2007)



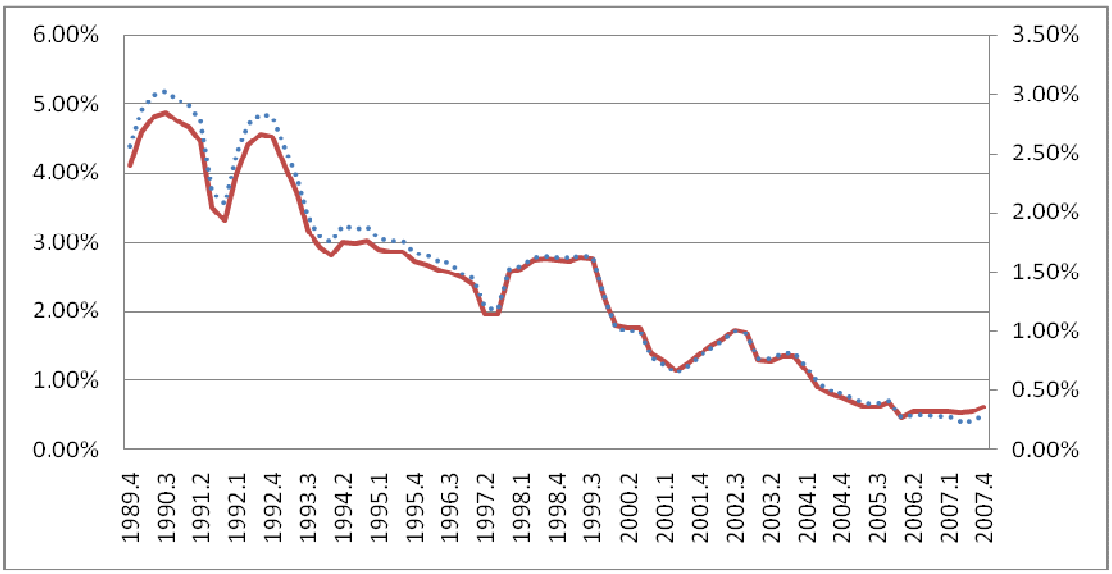
Note: Consumption, investment, and government spending are on the left scale, net export is on the right scale.

From 1997, the volatility of each component decreased significantly except government spending. By taking into account of the weight of each component, investment and consumption contributed the most to the decline in output volatility.

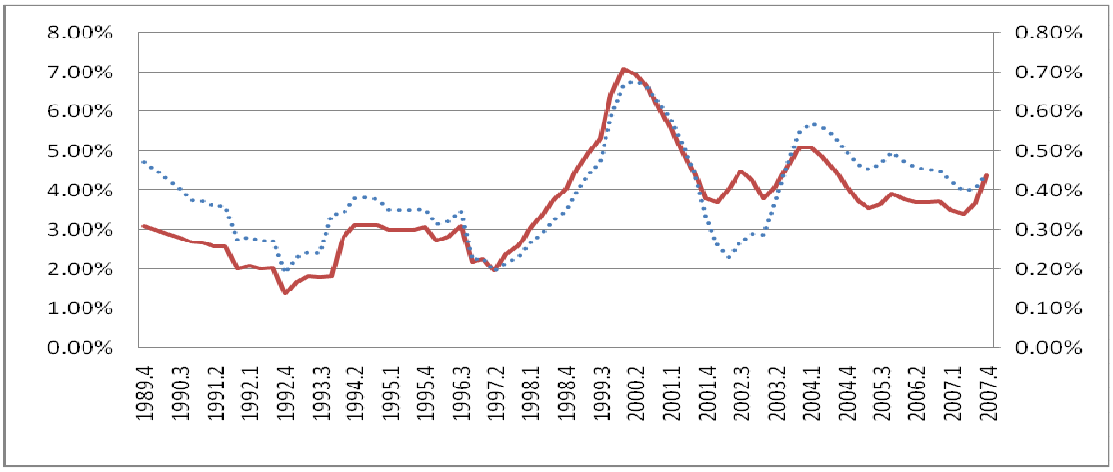
The two measures are plotted together in Figure 4.9 (see Appendix 8 and 9). The solid line represents the rolling standard deviation of growth rate, and the dash line represents the rolling standard deviation of growth contribution. The "growth contribution" adjusts for the share of the GDP component, if the two measures move together at high frequency reflecting the stability of the shares.

Figure 4.9 Volatilities Components of GDP (1989-2007)

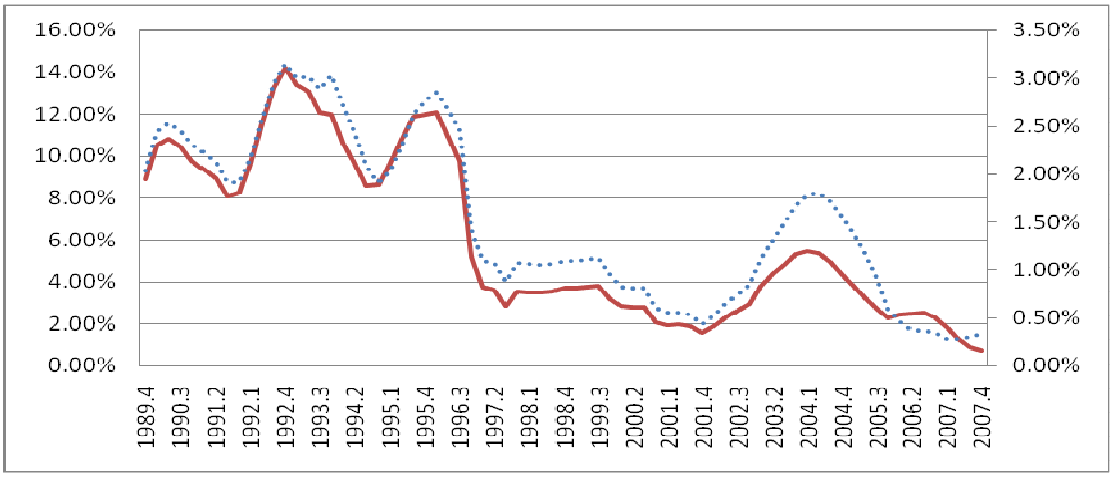
a. Consumption



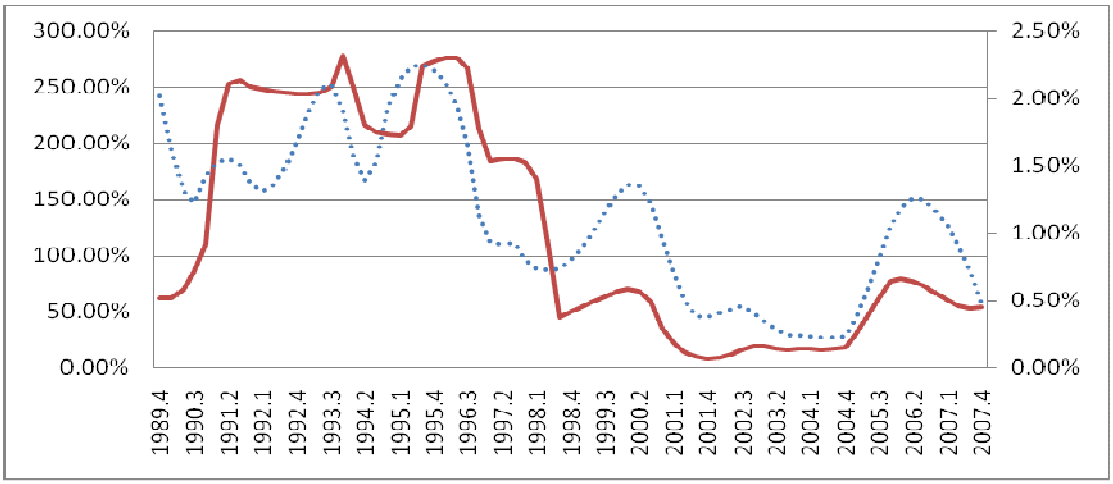
b. Government Spending



c. Investment



d. Net Export



Note: ___ Twelve-quarter rolling standard deviation of quarterly growth rate: left scale

…... Twelve-quarter rolling standard deviation of growth contribution: right scale

From Figure 4.9 we draw the following conclusions:

First, the rolling standard deviation of the growth rate and the rolling standard deviation of the growth contribution move together at high frequency besides net export, reflecting the stability of the shares. However, the share of consumption decreased gradually over the sample period. In contrast, the share of investment increased significantly over the sample period, especially from 2002 to 2005.

Figure 4.9d shows the rolling standard deviation of net export growth rate and the rolling standard deviation of net export growth contribution. The volatility of net export has the obvious boundary nature. Prior to 1998, the net export volatility maintained at a high level of around 225 per cent. After 1998, the net export volatility dropped dramatically to approximately 50 per cent, and the share of net export increased notably and remained thereafter. The character of the net export volatility is mainly because of China's unstable international trade policies. Before the pre-reform and opening up era, China was largely a closed economy with little external trade. Within the scope of broad economic reforms under Deng Xiaoping in 1978, an open-door trade and investment policy was introduced. Special Economic Zones along the coast are set up for foreign investment. From 1986 to 1989, trade became decentralized as China strived to integrate itself into the world trade system. Japan is China's dominant trading partner, followed by Hong Kong and the U.S. As a result, the volatility of net export increased 5 times from 50 per cent in 1989 to 250 per cent in 1991. Foreign investment grew tenfold between 1990 and 1995. During this period,

the net export volatility sustained at a high level, because of unwieldy contractual and legal framework, China's billion customers attracted many investors, especially from ethnic Chinese from Hong Kong and Taiwan. In November 1999, the U.S. and China arrived at a bilateral market-access agreement that paves the way for China's accession to the World Trade Organization, and smoothed the net export volatility. In 2000, China reached a bilateral WTO agreement with the European Union and other trade partners and begins work on a multilateral WTO accession package. To increase exports, China encouraged the formation of factories that assemble imported components into consumer goods for export. The U.S. approved permanent trade relations with China, and President Clinton signed the China Trade Relations Act of 2000. In 2001, China served as the Asia Pacific Economic Group's (APEC) chair; Shanghai hosted the annual APEC leaders meeting. After the 2001 World Trade Organization summit in Qatar, China became a full member of the WTO, which smoothed the net export volatility further. Many tariffs and regulations are streamlined or ended, but foreign investors still face procedural obstacles. For example, major trading partners complain that the Chinese currency is undervalued.

Second, the volatility of government spending was very low from 1989 to 1997. It increased rapidly in the late 1990s and has remained high ever since. One possible explanation is, from 1997 to 2000, China’s GDP growth rate dropped due to the 1997 Asian financial crisis. The central government adjusted its macroeconomic regulations in 1998, focusing on expansionary fiscal policy and prudent monetary policy to

defend against the negative effects of the Asian financial crisis. Consequently, the government spending increased sharply reached the peak point 7 per cent in 2000. The standard deviation of government spending growth contribution is nearly the same in early 2000s as in the 1990s.

Third, most of the decrease in output volatility trend can be traced to a decrease in the volatility of consumption and investment. After a large decrease in the early 1990s, consumption volatility has continued to decrease, from about 3 per cent in 1994 to 0.3 per cent in the late 2000s. The decrease in investment volatility has been more obvious. Since 1996, the volatility of investment declined from 12 per cent to only 0.2 per cent in 2007.

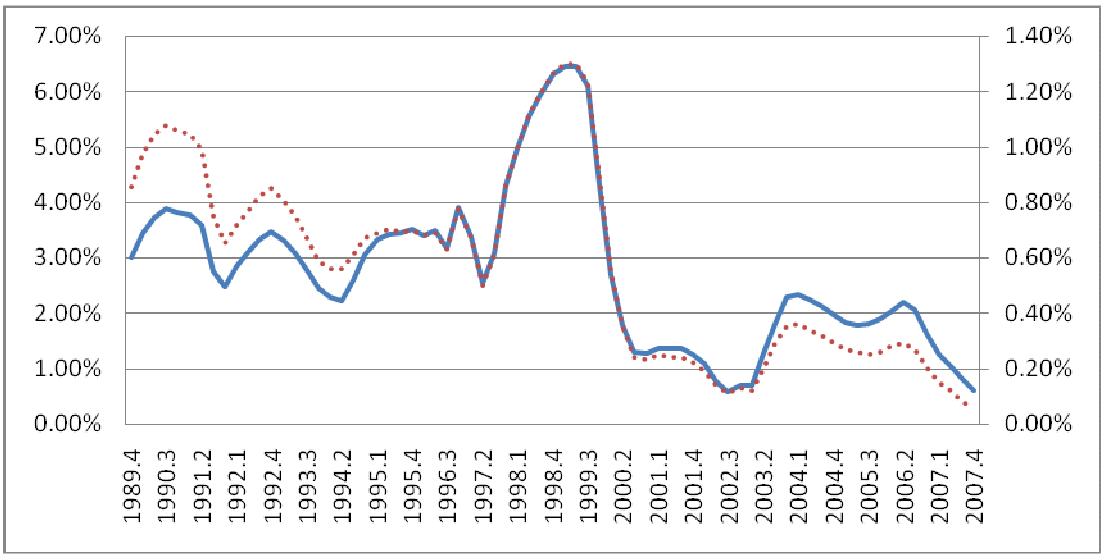
This is because of the improvements in living standards in China, where people have more disposable income to better allocate their expenses and investment. Consumption rose notably high with more money spent on housing and people having more savings deposits, foreign exchange deposits, stocks and other financial assets. In addition, the consumption structure changed remarkably with reduced spending on basic daily necessities and increased spending on housing, communication, medical insurance, education, and entertainment. Improvements in financial markets are another possible explanation for the reduction in consumption and investment volatility. For given interest rates, they plausibly lead to a decrease in the volatility of consumption and investment, which allowed the consumers to adjust faster toward

their desired goods.

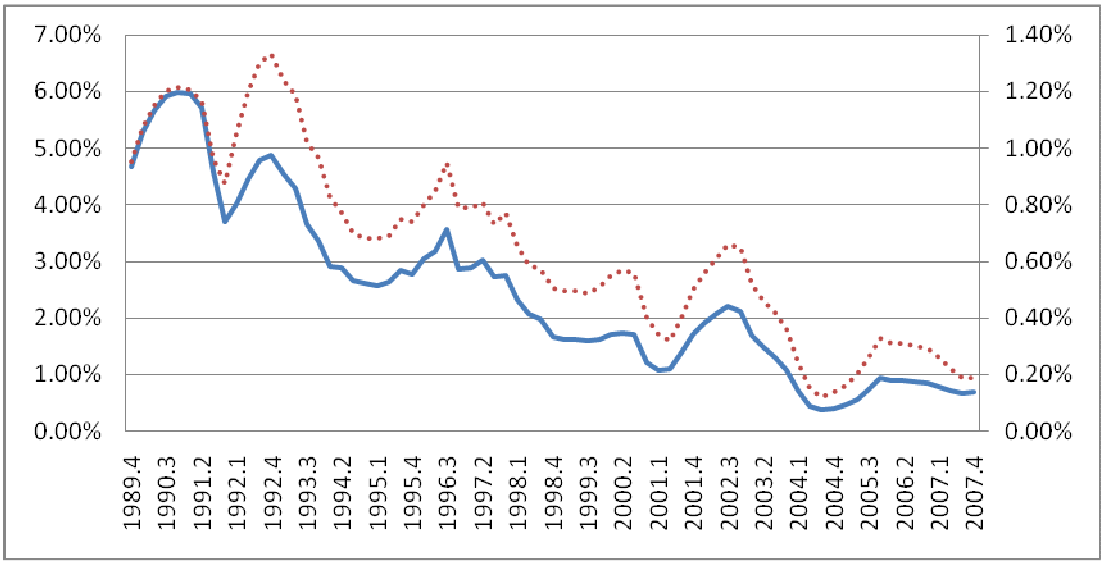
Given that much of the action comes from consumption and investment, Figures 4.10 (see Appendix 10) and 4.11 (see Appendix 11) go one step further in disaggregation to trace the volatility of the components of consumption and investment.

Figure 4.10 Volatilities Components of Consumption (1989-2007)

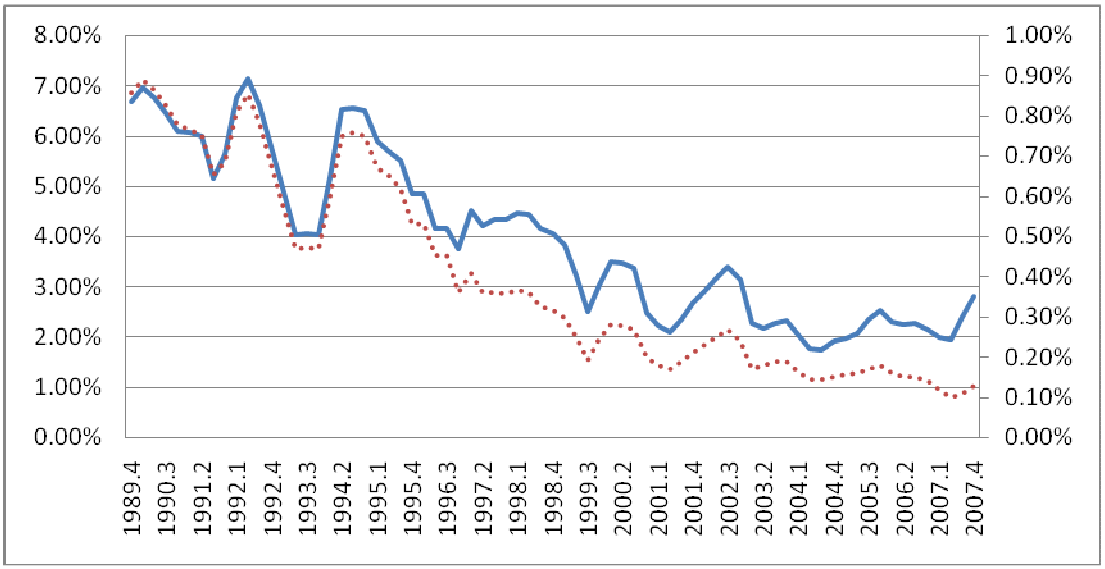
a. Rural Consumption Expenditure



b. Urban Consumption Expenditure



c. Government Consumption Expenditure



Note: ___ Twelve-quarter rolling standard deviation of quarterly growth rate: left scale

…... Twelve-quarter rolling standard deviation of growth contribution: right scale

Figure 4.10 shows the relative declines in the volatility of all three components of consumption: rural, urban, and government expenditures exhibit quite different patterns. The share of urban consumption expenditure increased, whereas the share of government consumption expenditure decreased over the sample period. The share of rural consumption expenditure increased before 1998, but decreased thereafter.

The reduction in the share of government consumption expenditure mainly resulted from the government's expenditure-saving efforts in response to the unfavorable condition in public finances. The separation of rural and urban sectors has been a major feature of the Chinese economy. Shortly after establishing the socialist regime in 1949, China started a development strategy that emphasized urban industries with capital intensive technology. Extracting agriculture surplus and retaining profits in

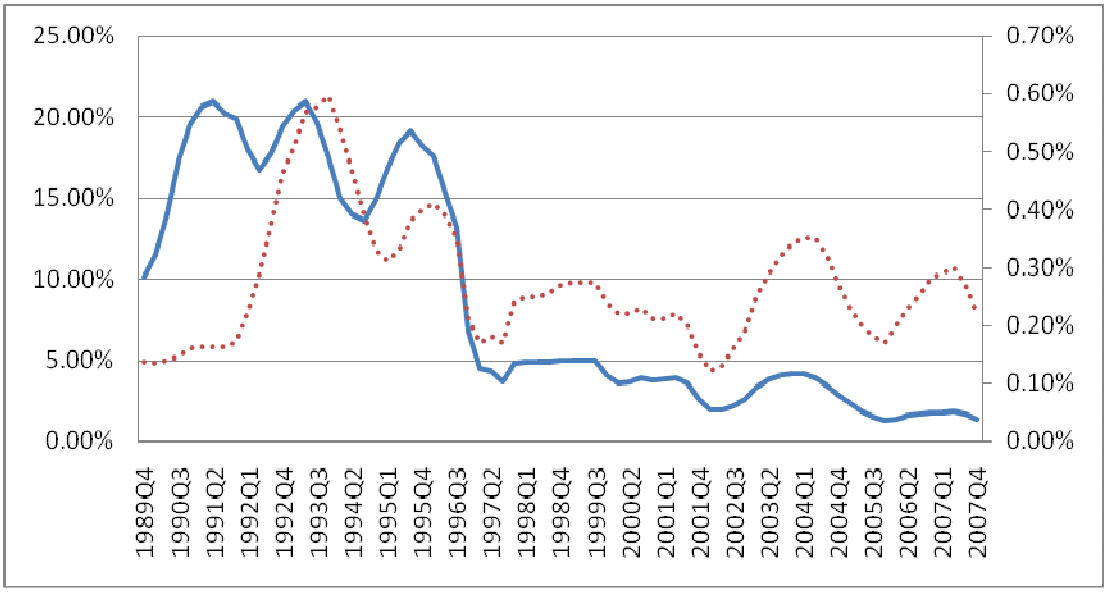
industries were the key sources of capital accumulation. Prior to the start of economic reforms in 1978, capital goods were excessively concentrated in the urban sector and a large fraction of the labour force was restrained from leaving the agriculture sector. As a result urban workers productivity, earnings, and consumption levels exceeded rural counterparts. As part of the reforms, a series of policies have been introduced to reduce the rural-urban division. For example, increases in procurement prices for agricultural products, liberalizing local markets, the relaxation of restrictions on labour mobility to cities, and capital investment in rural industries. The remarkable successes are the rapid increases in farmers' earnings, and the development of rural industries, which have become a powerful source of economic growth. After China became a member of WTO in 2001, foreign investment surges to a record high. Strong growth masks internal disparities between cities and rural areas, coastal and interior regions. Consequently, the share of rural consumption expenditure decreased since 2002.

Both urban consumption expenditure volatility and government consumption expenditure volatility decreased gradually over the sample period, from 5.5 percent to 0.9 percent, and from 7 percent to 2.5 percent respectively. In contrast, the volatility of rural consumption expenditure shows a sharp increase from 1997 to 1998 and a rapid decrease thereafter. The structural break took place sometime in 1998 toward stabilization, thus the rural consumption expenditure contributes the most to the decline in output volatility.

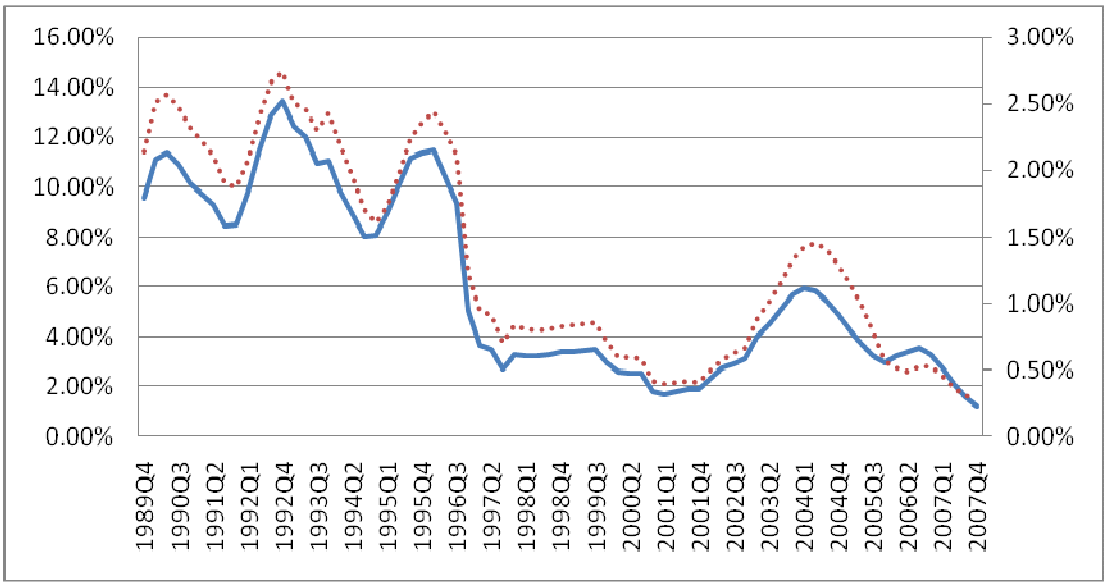
The declines in the volatility of the two components of investment: residential investment and nonresidential investment are quite similar, as the volatilities of residential and nonresidential investment were very high between 1989 and 1996, and both fell rapidly since the fourth quarter of 1996. However, the investment structure has changed which was evidenced by a large increase in the share of residential investment. Since 1990, real estate markets of big cities in China were overheated. When China opened up its real estate market in 1998, luxury apartments, and Western-style villas have been popping up around major cities throughout the country. Both foreign and domestic investors have funneled money into the market. Large profits that are made from the rising cost of housing are the attractive force. The market is hot, but some worry that it might be overheating. Despite the positive impact of rising values have had on the national economy, the Chinese government is seeking to find a more sustainable pace of development. In an attempt to bring greater stability to the market, the government has enacted several moderating policies. The most recent and significant of which is the New Property Law. This law takes effect on 1 October 2007, providing equal guarantees for private property and public assets and is aimed at "safeguarding the fundamental interests of the people". The volatility of residential investment decreased from about 20 percent in the early 1990s to 0.5 percent in 2000s. Nonresidential investment shows a steady decline and a limited increase in mid-2000. Figure 4.11b shows that the standard deviation of nonresidential investment's growth rate and growth contribution move together at high frequency, which means the stability of the shares.

Figure 4.11 Volatilities Components of Investment (1989-2007)

a. Residential Investment



b. Nonresidential Investment



Note: ___ Twelve-quarter rolling standard deviation of quarterly growth rate: left scale

…... Twelve-quarter rolling standard deviation of growth contribution: right scale

4.6 Conclusion

The results of this study support some key findings from the existing literature on "The Great Moderation". By examining the output volatility in China we found that before 1999, the standard deviation of China quarterly real GDP growth rate was 3.96%, but decreased to 1.48% after 1999, a decline of more than half. The moderation generally is associated with reductions in the variance of GDP growth rate, not with changes in the mean of GDP growth rate. The rolling standard deviation of quarterly growth rate of real GDP shows a clear decline in the standard deviation over time, from about 4.5 per cent a quarter in the late 1980s to less than 1 per cent in the late 2000s.

We used the CUSUM squares test and the Quandt-Andrews breakpoint test to identify unknown structural breaks and we found two structural breaks: 1994:1 towards destabilization and 1998:1 towards stabilization. In terms of autoregression, the variance reduction is attributable to a smaller error variance, not to changes in the autoregressive coefficients. The standard deviation of the regression residuals showed the same time pattern as the standard deviation of output growth rate, which shows the decrease in output volatility appears to come from smaller external shocks, rather than from a decrease in the persistence of the effects of these shocks on output.

Having establishing this fact, we reached two other conclusions. First, there is a strong relationship between the movements in output volatility and the movements in

inflation volatility. The sharp decline in output volatility in the 1990s is positively associated with a sharp decline in inflation volatility at that time. Second, the decrease in output volatility can be traced to a decrease in the volatility in consumption, investment, and net export. Following this, we decomposed the GDP components to trace the volatility of consumption and investment components, and found that rural consumption expenditure and residential investment contributed the most to the decline in output volatility.

Chapter 5

SUMMARY AND CONCLUSIONS

5.1 Introduction

This chapter summarizes the previous chapters and draws conclusions regarding the large decline in China's output volatility. Section 5.2 reviews the main findings of the study. Section 5.3 draws conclusions pertaining to research question 1. Section 5.4 draws conclusions pertaining to research question 2. Section 5.5 draws conclusions pertaining to research question 3. Section 5.6 provides implications for Chinese policymakers. Section 5.7 outlines the limitation of the study and Section 5.8 discusses the recommendations for future research.

5.2 Summary, Major Findings and Discussion

This thesis examines the output volatility in China and tests whether the standard deviation of quarterly output growth rate has declined dramatically. This includes an examination of the stochastic process for GDP and whether this decrease in volatility can be traced primarily to a decrease in the standard deviation of output shocks, rather than to a change in the dynamics of output. By using the CUSUM squares test and the Quandt-Andrews breakpoint test to identify unknown structure breaks, our study identifies two structural breaks: 1994:1 towards destabilization and 1998:1 towards stabilization.

This thesis addresses the following research questions in analyzing the real output fluctuation in China:

- First, we examine the evidence and the nature of the decline in output volatility in China
- Second, is there one or more structural breaks in the Chinese real GDP growth rate towards stabilization or destabilization, if yes, when did these happen?
- Third, what are the reasons for the changes in patterns of output volatility in China?

This study documents the long and large decline in output volatility over the last twenty years in China. In addition, this study identifies the timing of the structural break and the proximate causes for the changes in the patterns of output volatility. The empirical results show that there are two structural breaks: 1994:1 towards destabilization and 1998:1 towards stabilization.

Our results show that this large decline in output volatility has many proximate causes. Among them are a sharp decrease in the volatility of consumption, investment, and net export, especially in rural consumption expenditure and residential investment. The major causes of the decrease in volatility are due to the role of monetary policy.

Our findings suggest that monetary policy has played a complex role. The dramatic decrease in output volatility in the late 1990s can be interpreted in two ways, both

related to monetary policy. The first is that this decrease was indeed the result of smarter countercyclical policy, leading to better output stabilization. The other interpretation is that the decrease in output volatility was associated with and has been largely caused by the decrease in inflation volatility that occurred around the same time. Better monetary policy leads to lower and more stable inflation, and provides a more favorable economic environment to achieve more stable output growth.

It is difficult to comprehend whether the Great Moderation is permanent or transitory. A repetition of shocks as large as those in the 1970s may lead to an increase in cyclical volatility. China's rapid and stable economic growth and its success in precluding serious inflation are not only beneficial to the country, but also favor international trade and foreign investment in China. Continued improvements in China’s business environment, for example, its predictability and transparency are removing key barriers that have long weakened foreign investor confidence.

China’s increasing integration with the global economy has contributed to sustained growth in international trade. Its exports have become more diversified, and greater penetration of industrial country markets has been accompanied by a surge in China’s imports from all regions. With its WTO accession, China has committed itself to implement additional tariff reforms, and foreign investment surges to a record high. Sustained implementation of these commitments would further deepen China’s international integration and generate benefits for most partner countries.

5.3 Conclusions Pertaining to Research Question 1

By examining the output volatility in China we found that before 1999, the standard deviation of China quarterly real GDP growth rate was 3.96%, but dropped to 1.48% after 1999, a decline of more than half. Figure 4.2 reports the rolling standard deviation of the quarterly growth rate of the real GDP since the fourth quarter of 1989, which shows a clear decline in the standard deviation over time, from about 4.5 per cent a quarter in the late 1980s to less than 1 per cent in the late 2000s. Table 4.1 shows the moderation generally is associated with reductions in the variance of GDP growth rate, not with changes in the mean of GDP growth rate.

Blanchard and Simon (2001) documented that the standard deviation of the U.S. quarterly growth in real output has declined by half since the mid-1980s. In addition, Kent et al. (2005) found on average, the standard deviation of the GDP growth rate of the 20 selected OECD countries has dropped over one percentage point since the 1970s. To compare with the GDP volatility decline in the U.S. and the 20 selected OECD countries, China has experienced a larger and more significant decline than those countries.

5.4 Conclusions Pertaining to Research Question 2

The data in Table 4.3 reports the Quandt-Andrews unknown structural break test of residual variance of the real GDP growth rate. The estimated structural break date of 1998:1 is consistent with the findings of Gregorio (2008) that in developing countries

the Great Moderation was achieved about ten years ago and coincidentally with low inflation. Gregorio found both inflation and output growth volatility declined since mid-1990s in developing economics. In addition, Gregorio pointed out that lagged monetary policy reforms, central bank independence, inflation targeting, and other related policy reforms occurred in developing economies in the mid-1990s, which coincides with the decline in volatility in developing countries. On the contrary, the findings of previous literatures suggested the decline in the U.S. macroeconomic volatility occurred from the early 1980s to the middle of 1980s. The reductions in volatility took place earlier in Germany, Italy, France, and the United Kingdom, followed by Canada and the U.S. (Summers, 2005). The volatility reduction in Australia happened almost the same time as the U.S. in the mid-1980s. However, Japan experienced low variability in the 1980s and experienced high variability in the 1990s.

China's output growth rate has shown a marked stability in the late 1990s compared to previous decades. "*The Great Moderation"* happened in China almost 15 years later than the G-7 nations and other developed countries. Since the founding of the People's Republic of China in 1949, China has experienced a three-year natural disaster and the Great Cultural Revolution, which took almost 20 years later to develop the country compared to the western world. As a consequence of successful policy in the reform period, Chinese per capita income rose by 6.6 per cent a year from 1978 to 2003, faster than any other Asian country, much better than the 1.8 per

cent a year in Western Europe and the United States and four times as fast as the world average (OECD Development Centre, 2008). Its share of world GDP rose from 5 to 15 per cent and it became the world's second biggest economy, after the United States.

5.5 Conclusions Pertaining to Research Question 3

Figure 4.4 and Figure 4.5 report the estimations of autoregression (AR) model, neither the AR (1) coefficient nor the growth rate shows a clear movement over time. The standard deviation of the regression residual decreased from about 4.5 per cent in the early 1990s to less than 1 per cent in 2000s, which showed the same time pattern as the standard deviation of output growth rate. This conclusion is consistent with the findings of Blanchard and Simon (2001) and Rafferty (2003).

Figure 4.6 shows the relationship between output volatility and inflation. The correlation between the level of inflation and output growth volatility is 0.778, and the correlation between inflation volatility and output growth volatility is 0.779. In short, output and inflation volatilities have had a strong tendency to move together. This finding is consistent with Taylor (2000) and Blanchard and Simon (2001).

Descend in the volatilities of consumption, investment, and net export make up the main reasons for the changes in economic fluctuation mode. According to the disaggregation on consumption and investment, rural consumption expenditure and

residential investment played the most important role in reducing GDP volatility. Stock and Watson's (2002) study showed the reduced volatility extended to several sectors of the economy, particularly durable goods, and residential investment. Although China is a developing country, these findings are quite similar to the findings of previous literatures in the U.S. McConnell et al. (1999) examined changes in the U.S. growth rate volatility in the major components of GDP aggregate, and showed that residential investment, exports, and imports experienced the largest absolute declines in growth volatility. Blanchard and Simon (2001) documented that most of the decrease in the U.S. output volatility can be traced to a decrease in the volatility of consumption and investment, and consumption of services and residential investments contributed the most to the decline in output volatility in the U.S.

The results from the autoregression model in Section 4.4 suggests that the reductions in volatility evidenced in Figure 4.1 and Figure 4.2 are associated with changes in error variances (conditional variances), rather than changes in autoregressive coefficients (conditional mean). In addition, the estimations of the autoregression model indicates the decrease in output volatility appears to come from smaller external shocks, such as changes in oil prices, monetary policy, and technology shocks, rather than from a decrease in the persistence of the effects of these shocks on output.

5.6 Implications for Policymakers

Lower output volatility suggests lower risk, and thus changes in risk premiums and precautionary saving. With a lower volatility in output, the employment will be more stable, and the households and firms face less economic uncertainty. The decrease in output volatility appears sufficiently steady and a major reversal appears unlikely. This implies a much smaller likelihood recessions. Since the start of *"The Great Moderation"*, the length of business-cycle expansions becomes longer. For example, the U.S. economy has gone through two long expansions since the early 1980s. The first expansion is from 1982 to 1990, which lasted thirty-one quarters. The second expansion started in 1991, which has recorded its fortieth quarters and is already the longest U.S. expansion on record (Blanchard and Simon, 2001). Since recessions are defined as periods of absolute decline in economic activity, reduced volatility with the same mean growth rate implies fewer and shorter recessions (Stock and Watson, 2002). As discussed by Kim and Nelson (1999), Blanchard and Simon (2001), and Pagan (2000), this suggests that the decrease in the variance of GDP has played a major role in the increased length of business-cycle expansions over the past two decades.

The introduction of reforms and opening-up policy initiated by the late Deng Xiao-ping in 1978 reduced the difference between China and Western countries. China's opening-to-the-world economy has been remarkably trouble free by comparison with similar situation in some other Asian and Latin American countries.

The strong relationship between movements in output volatility and the movements in inflation volatility suggests that monetary policy plays an important role in reducing output volatility indirectly by getting inflation under control, since prudent monetary policy provides a more favorable economic environment to achieve more stable output growth. Therefore, policymakers in China should continue to implement the monetary policy in the same way. Sustaining the stability of consumption, investment, and net export are crucial. The Chinese government should continue to improve financial market regulations in an attempt to bring greater legal stability to the market and continuing maintain stable international trade policies. Furthermore, the Chinese government should find a more sustainable pace of development in order to prevent the real estate sector from overheating.

5.7 Limitation of the Study

There are a few limitations in this study. First, the post-reform period should be 29 years from 1978 to 2007. However, the sample period in this study is 20 years from 1987 to 2007 due to the data limitations, which may reduce the robustness of the study.

Second, most of the data obtained from China Statistical Yearbook are annual data. In order to obtain quarterly data we adopted a low to high frequency conversion option – linear-match last method in EViews program. The converted data includes inflation rate, consumption, rural consumption expenditure, urban consumption expenditure,

government consumption expenditure, investment, residential investment, nonresidential investment, government spending, and net export. The linear-match last method assigns each value in the low frequency series to the last high frequency observation associated with the low frequency period, then places all intermediate points on straight lines connecting these points. Since observing a series at a lower frequency provides fundamentally less information than observing the same series at a higher frequency, it is generally not possible to recover the high frequency series from the low frequency data. Consequently, biasness may exist as the results from EViews' interpolation methods are not the true values of the underlying series.

Third, the GDP components collected from China Statistical Yearbook are nominal values, and real values are not available. In order to obtain real terms, the GDP deflator has been used to convert nominal values to real values, thus biasness may exist.

Fourth, to interpret the changes in the output process, we assume the process to be first-order autoregressive AR (1). Although all of our conclusions extend to higher-order AR processes, this may not fully capture the dynamics of output growth (Table A3).

Fifth, China changes monetary policy system during the sample period. In 1998, the national bank credit quota was scrapped and the People's Bank of China began open

market operations in October the same year. Since then, the People's Bank of China has had to rely on adjusting its own balance sheet to manage the monetary base. The three main monetary policy instruments are open market operations (OMO), discount rate and reserve requirements. Therefore, the impact of inflation on the decline in output volatility is limited compared to the U.S.

5.8 Recommendations for Future Research

In this study, we examined only the proximate causes of the output volatility decline in China. Future studies are encouraged to identify other causes, such as changes in financial markets to better countercyclical policy. The relative roles of monetary policy and financial market improvements in reducing output volatility is an interesting issue. For example, the output volatility increased significantly in Japan in the 1990s. Monetary policy is limited by the constraint that interest rates be nonnegative. Since the Japanese banks faced similar problems, intermediation was clearly disrupted. Was the increase due to monetary policy or to changes in financial markets or something else? The answer is far from obvious, unless a more detailed examination is conducted.

The sample period is 20 years from 1987 to 2007, future studies might consider a longer post-reform period from 1978 to 2007. The pre-reform and opening up era are excluded from our sample because of the negative effects of ten-year natural disaster and Great Cultural Revolution. Future studies are encouraged to test the robustness of

the results. If the results are inconsistent, the data during the pre-reform period should be considered to be a serious source of concern.

The 1997 Asian financial crisis period is included in our sample. Future studies are encouraged to use the sensitivity analysis to compare the results of the dataset that include the crisis period with those results exclude the crisis period. If the result of the sensitivity analysis is consistent and similar for the two datasets, this suggests that the exclusion of the data during the crisis period had little or no effect on the overall conclusions.

Third, to interpret the changes in the output process, we assumed the process to be first-order autoregressive AR (1). Future research should try to extend to higher-order AR processes, which may better capture the dynamics of output growth.

An important unresolved question in the literature is whether the moderation was a sharp break in the mid-1980s, as initially suggested by Kim and Nelson (1999), or part of an ongoing trend, as suggested by Blanchard and Simon (2001). Future researchers are encouraged to focus on this disparity to solve the question. In addition, lower output volatility suggests lower risk and thus changes in risk premiums. However, Ferguson (2005) concluded that decrease in output volatility has not been reflected in a parallel decrease in asset price volatility. These issues should be explored in the future.

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Appendix 1

China Quarterly Real GDP Growth Rate (1987-2007)

Year	Real GDP	Real GDP Growth Rate
1987.1	6698.64	12.04%
1987.2	6738.81	12.21%
1987.3	6833.11	11.73%
1987.4	7340.73	10.43%
1988.1	7436.22	11.01%
1988.2	7469.88	10.85%
1988.3	7791.52	14.03%
1988.4	8024.76	9.32%
1989.1	8124.01	9.25%
1989.2	7973.84	6.75%
1989.3	7824.94	0.43%
1989.4	8048.81	0.30%
1990.1	8138.54	0.18%
1990.2	8174.37	2.51%
1990.3	8182.66	4.57%
1990.4	8701.62	8.11%
1991.1	8824.99	8.43%
1991.2	8864.87	8.45%
1991.3	8901.13	8.78%
1991.4	9658.40	11.00%
1992.1	10120.39	14.68%
1992.2	10045.66	13.32%
1992.3	10166.19	14.21%
1992.4	11078.86	14.71%
1993.1	11146.55	10.14%
1993.2	11566.47	15.14%
1993.3	11275.68	10.91%
1993.4	13008.30	17.42%
1994.1	12259.10	9.98%
1994.2	12529.25	8.32%
1994.3	13124.73	16.40%
1994.4	15035.11	15.58%
1995.1	13981.89	14.05%
1995.2	13910.64	11.03%
1995.3	14191.08	8.12%
1995.4	16426.88	9.26%
1996.1	15208.50	8.77%
1996.2	15037.39	8.10%
1996.3	15353.61	8.19%

Year	Real GDP	Real GDP Growth Rate
1996.4	18520.50	12.75%
1997.1	17107.14	12.48%
1997.2	16472.15	9.54%
1997.3	16699.97	8.77%
1997.4	19485.54	5.21%
1998.1	18339.03	7.20%
1998.2	17628.28	7.02%
1998.3	18141.49	8.63%
1998.4	21100.49	8.29%
1999.1	19708.18	7.47%
1999.2	18702.15	6.09%
1999.3	19291.82	6.34%
1999.4	22857.34	8.33%
2000.1	21554.33	9.37%
2000.2	20189.47	7.95%
2000.3	20692.51	7.26%
2000.4	24567.88	7.48%
2001.1	23364.89	8.40%
2001.2	21845.01	8.20%
2001.3	22265.14	7.60%
2001.4	26410.47	7.50%
2002.1	25234.09	8.00%
2002.2	23636.30	8.20%
2002.3	24113.15	8.30%
2002.4	28602.54	8.30%
2003.1	27732.26	9.90%
2003.2	25645.38	8.50%
2003.3	26210.99	8.70%
2003.4	31205.37	9.10%
2004.1	30450.02	9.80%
2004.2	28261.21	10.20%
2004.3	28805.88	9.90%
2004.4	34169.88	9.50%
2005.1	33464.57	9.90%
2005.2	31115.59	10.10%
2005.3	31628.86	9.80%
2005.4	37552.70	9.90%
2006.1	36911.42	10.30%
2006.2	34693.89	11.50%
2006.3	35013.14	10.70%
2006.4	41458.18	10.40%

Year	Real GDP	Real GDP Growth Rate
2007.1	41008.59	11.10%
2007.2	38822.46	11.90%
2007.3	39039.65	11.50%
2007.4	46101.50	11.20%

Source: Gu (2004), PhD Thesis, American University.

Appendix 2

EViews Output of Unit Root Test of GDP Growth Rate

Null Hypothesis: Yt has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.003243	0.0387
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YT)
Method: Least Squares
Date: 02/01/09 Time: 23:28
Sample (adjusted): 1987Q3 2007Q4
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
YT(-1)	-0.248535	0.082755	-3.003243	0.0036
D(YT(-1))	-0.107477	0.111575	-0.963275	0.3383
C	0.023330	0.008181	2.851695	0.0055

R-squared	0.150380	Mean dependent var	-0.000124
Adjusted R-squared	0.128870	S.D. dependent var	0.023494
S.E. of regression	0.021928	Akaike info criterion	-4.766229
Sum squared resid	0.037985	Schwarz criterion	-4.678179
Log likelihood	198.4154	Hannan-Quinn criter.	-4.730878
F-statistic	6.991355	Durbin-Watson stat	1.982348
Prob (F-statistic)	0.001601		

Appendix 3

First-order Autoregression Model of GDP Growth Rate

Dependent Variable: Yt
Method: Least Squares
Date: 01/11/09 Time: 18:04
Sample (adjusted): 1987Q2 2007Q4
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.380397	0.709677	3.354195	0.0012
Yt-1	0.734721	0.075021	9.793513	0.0000

R-squared	0.542148	Mean dependent var	8.998226
Adjusted R-squared	0.536495	S.D. dependent var	2.901795
S.E. of regression	1.975577	Akaike info criterion	4.223399
Sum squared resid	316.1352	Schwarz criterion	4.281685
Log likelihood	-173.2711	Hannan-Quinn criter.	4.246815
F-statistic	95.91290	Durbin-Watson stat	2.134997
Prob (F-statistic)	0.000000		

Appendix 4

EViews Output of Quandt-Andrew Breakpoint Test (1987-2007)

Quandt-Andrews unknown breakpoint test

Null Hypothesis: No breakpoints within trimmed data

Varying regressors: All equation variables

Equation Sample: 1987Q2 2007Q4

Test Sample: 1990Q3 2004Q3

Number of breaks compared: 57

Statistic	Value	Prob.
Maximum LR F-statistic **(1998Q1)**	19.09199	0.0003
Maximum Wald F-statistic (1998Q1)	19.09199	0.0003
Exp LR F-statistic	7.598279	0.0000
Exp Wald F-statistic	7.598279	0.0000
Ave LR F-statistic	10.44457	0.0000
Ave Wald F-statistic	10.44457	0.0000

Note: probabilities calculated using Hansen's (1997) method

Appendix 5

Estimations of First-order Autoregression model (1989-2007)

	AR(1) Coefficient			Estimated Average GDP Growth Rate			Standard Deviation of
Year	lower 95%	a	upper 95%	lower 95%	g	upper 95%	Regression Residuals
1989.4	0.1170	1.0899	2.0627	7.15%	9.51%	11.87%	3.43%
1990.1	-0.3231	0.9350	2.1932	5.46%	8.50%	11.55%	4.37%
1990.2	-0.7504	0.5332	1.8167	4.06%	7.28%	10.50%	4.78%
1990.3	-0.8047	0.3972	1.5992	3.46%	6.55%	9.64%	4.69%
1990.4	-0.6317	0.4372	1.5062	3.32%	6.23%	9.14%	4.52%
1991.1	-0.6205	0.4145	1.4494	3.22%	6.04%	8.85%	4.37%
1991.2	-0.5764	0.4173	1.4109	3.15%	5.85%	8.55%	4.19%
1991.3	-0.7450	0.1906	1.1263	3.03%	5.46%	7.88%	3.73%
1991.4	-0.3905	0.5960	1.5825	3.10%	5.43%	7.77%	3.62%
1992.1	-0.1469	0.8554	1.8577	3.01%	5.57%	8.12%	3.92%
1992.2	-0.4173	0.7827	1.9828	3.04%	6.02%	9.00%	4.54%
1992.3	-1.8082	0.4525	2.7132	3.01%	7.00%	10.98%	4.92%
1992.4	-2.3155	-0.1155	2.0845	4.84%	8.73%	12.62%	4.68%
1993.1	-1.5406	-0.3312	0.8782	7.09%	9.65%	12.22%	3.70%
1993.2	-0.7701	0.1782	1.1264	7.92%	10.19%	12.45%	3.22%
1993.3	-0.3920	0.2514	0.8948	9.08%	10.72%	12.37%	2.51%
1993.4	0.0514	0.5645	1.0775	9.67%	11.15%	12.63%	2.23%
1994.1	0.0976	0.4722	0.8469	10.31%	11.60%	12.89%	2.01%
1994.2	0.1506	0.5028	0.8550	10.43%	11.65%	12.87%	1.90%
1994.3	0.2479	0.4956	0.7432	10.93%	11.93%	12.93%	1.54%
1994.4	0.2546	0.5017	0.7487	11.39%	12.38%	13.37%	1.53%
1995.1	0.2363	0.4973	0.7584	11.50%	12.52%	13.55%	1.59%
1995.2	0.2527	0.5101	0.7675	11.39%	12.42%	13.44%	1.59%
1995.3	0.2475	0.5439	0.8403	10.92%	12.12%	13.32%	1.85%
1995.4	0.1725	0.5096	0.8466	10.31%	11.67%	13.04%	2.11%
1996.1	0.1346	0.5165	0.8984	9.94%	11.42%	12.90%	2.30%
1996.2	0.0626	0.5063	0.9501	9.48%	11.10%	12.73%	2.50%
1996.3	0.0396	0.5274	1.0152	9.03%	10.74%	12.45%	2.65%
1996.4	-0.0984	0.3892	0.8769	8.81%	10.42%	12.04%	2.50%
1997.1	-0.0761	0.5064	1.0889	8.80%	10.39%	11.97%	2.46%
1997.2	-0.0762	0.4765	1.0293	8.98%	10.53%	12.08%	2.40%
1997.3	-0.6104	0.2381	1.0866	8.54%	10.14%	11.74%	2.38%
1997.4	-0.2351	0.4667	1.1685	8.11%	9.59%	11.07%	2.14%
1998.1	-0.2087	0.3705	0.9497	7.66%	8.90%	10.14%	1.87%
1998.2	-0.0720	0.4949	1.0617	7.42%	8.55%	9.69%	1.74%
1998.3	-0.0994	0.4959	1.0912	7.29%	8.42%	9.55%	1.75%

	AR(1) Coefficient			Estimated Average GDP Growth Rate			Standard Deviation of
Year	lower 95%	a	upper 95%	lower 95%	g	upper 95%	Regression Residuals
1998.4	-0.1034	0.4999	1.1033	7.27%	8.40%	9.53%	1.76%
1999.1	-0.0915	0.5146	1.1207	7.18%	8.32%	9.46%	1.77%
1999.2	-0.0661	0.5577	1.1815	7.01%	8.20%	9.39%	1.85%
1999.3	-0.1208	0.5407	1.2022	6.78%	8.04%	9.31%	1.96%
1999.4	-0.5505	0.1961	0.9427	6.51%	7.70%	8.88%	1.80%
2000.1	-0.2712	0.2376	0.7464	6.64%	7.45%	8.27%	1.26%
2000.2	0.0093	0.4404	0.8714	6.70%	7.33%	7.96%	0.98%
2000.3	0.0923	0.4733	0.8543	6.66%	7.22%	7.77%	0.86%
2000.4	-0.1534	0.3351	0.8235	6.74%	7.28%	7.82%	0.83%
2001.1	0.0230	0.5117	1.0004	6.90%	7.38%	7.87%	0.75%
2001.2	-0.0011	0.4864	0.9740	6.99%	7.48%	7.96%	0.75%
2001.3	-0.0635	0.4692	1.0019	7.00%	7.48%	7.97%	0.75%
2001.4	-0.0280	0.4863	1.0006	6.95%	7.41%	7.88%	0.72%
2002.1	-0.0199	0.5023	1.0246	6.94%	7.40%	7.87%	0.72%
2002.2	-0.1918	0.3411	0.8741	7.10%	7.53%	7.96%	0.66%
2002.3	-0.0130	0.3539	0.7208	7.39%	7.69%	7.98%	0.45%
2002.4	0.0375	0.4987	0.9598	7.46%	7.74%	8.02%	0.43%
2003.1	0.1848	0.6245	1.0641	7.45%	7.75%	8.05%	0.47%
2003.2	-0.0112	0.5096	1.0303	7.44%	7.80%	8.15%	0.55%
2003.3	-0.0900	0.4470	0.9840	7.53%	7.88%	8.24%	0.54%
2003.4	-0.0138	0.4909	0.9956	7.66%	8.00%	8.33%	0.51%
2004.1	0.0779	0.6582	1.2385	7.72%	8.09%	8.47%	0.57%
2004.2	-0.0057	0.7125	1.4308	7.74%	8.21%	8.67%	0.71%
2004.3	-0.3439	0.4898	1.3235	7.88%	8.41%	8.94%	0.79%
2004.4	-0.4107	0.3366	1.0840	8.11%	8.59%	9.08%	0.73%
2005.1	-0.2407	0.4434	1.1274	8.29%	8.73%	9.16%	0.66%
2005.2	-0.1900	0.4578	1.1056	8.46%	8.87%	9.28%	0.63%
2005.3	-0.1699	0.4046	0.9792	8.64%	9.00%	9.37%	0.56%
2005.4	-0.0924	0.3757	0.8438	8.83%	9.13%	9.43%	0.46%
2006.1	-0.0569	0.5537	1.1644	8.88%	9.19%	9.49%	0.47%
2006.2	-0.0997	0.8018	1.7034	8.84%	9.25%	9.66%	0.55%
2006.3	-0.4190	0.3277	1.0745	9.16%	9.53%	9.90%	0.55%
2006.4	-0.2616	0.3590	0.9797	9.34%	9.65%	9.95%	0.46%
2007.1	-0.0171	0.5881	1.1933	9.43%	9.72%	10.02%	0.45%
2007.2	0.1323	0.8166	1.5009	9.45%	9.80%	10.16%	0.54%
2007.3	-0.2448	0.5898	1.4245	9.52%	9.96%	10.40%	0.66%
2007.4	-0.4605	0.3762	1.2130	9.67%	10.11%	10.54%	0.66%

Appendix 6 Relationship between Output Volatility and Inflation

Year	Rolling Standard Deviation of Real GDP Growth Rate	Rolling Standard Deviation of Inflation	Rolling Mean of Inflation
1989.4	3.99%	5.02%	13.06%
1990.1	4.50%	4.59%	13.71%
1990.2	4.54%	4.21%	14.03%
1990.3	4.40%	4.24%	14.01%
1990.4	4.29%	4.90%	13.66%
1991.1	4.14%	5.64%	13.08%
1991.2	3.99%	6.26%	12.28%
1991.3	3.44%	6.62%	11.25%
1991.4	3.60%	6.56%	9.99%
1992.1	4.17%	6.21%	8.81%
1992.2	4.56%	5.60%	7.70%
1992.3	4.54%	4.68%	6.67%
1992.4	4.28%	3.27%	5.73%
1993.1	3.44%	2.28%	5.25%
1993.2	2.96%	2.30%	5.26%
1993.3	2.38%	3.07%	5.75%
1993.4	2.58%	3.81%	6.72%
1994.1	2.45%	4.59%	7.87%
1994.2	2.46%	5.34%	9.22%
1994.3	2.43%	6.03%	10.75%
1994.4	2.44%	6.61%	12.48%
1995.1	2.43%	6.56%	13.95%
1995.2	2.49%	6.11%	15.17%
1995.3	2.76%	5.41%	16.14%
1995.4	2.82%	4.57%	16.86%
1996.1	2.90%	3.99%	17.26%
1996.2	2.93%	3.85%	17.35%
1996.3	3.05%	4.17%	17.13%
1996.4	2.62%	4.81%	16.60%
1997.1	2.64%	5.57%	15.71%
1997.2	2.57%	6.22%	14.48%
1997.3	2.21%	6.59%	12.89%
1997.4	2.15%	6.43%	10.95%
1998.1	1.87%	6.13%	9.16%
1998.2	1.86%	5.73%	7.53%
1998.3	1.86%	5.29%	6.06%
1998.4	1.86%	4.85%	4.74%

Year	Rolling Standard Deviation of Real GDP Growth Rate	Rolling Standard Deviation of Inflation	Rolling Mean of Inflation
1999.1	1.88%	4.32%	3.55%
1999.2	1.99%	3.73%	2.49%
1999.3	2.06%	3.09%	1.55%
1999.4	1.67%	2.41%	0.75%
2000.1	1.21%	1.73%	0.13%
2000.2	1.10%	1.10%	-0.29%
2000.3	1.05%	0.66%	-0.52%
2000.4	0.84%	0.60%	-0.55%
2001.1	0.85%	0.61%	-0.54%
2001.2	0.84%	0.66%	-0.50%
2001.3	0.81%	0.73%	-0.41%
2001.4	0.79%	0.78%	-0.29%
2002.1	0.80%	0.77%	-0.18%
2002.2	0.66%	0.72%	-0.09%
2002.3	0.50%	0.64%	-0.03%
2002.4	0.50%	0.55%	0.02%
2003.1	0.60%	0.48%	0.08%
2003.2	0.61%	0.45%	0.14%
2003.3	0.57%	0.47%	0.20%
2003.4	0.57%	0.54%	0.27%
2004.1	0.67%	0.70%	0.38%
2004.2	0.79%	0.92%	0.55%
2004.3	0.78%	1.18%	0.77%
2004.4	0.70%	1.47%	1.03%
2005.1	0.66%	1.58%	1.29%
2005.2	0.64%	1.58%	1.53%
2005.3	0.58%	1.48%	1.76%
2005.4	0.48%	1.26%	1.97%
2006.1	0.51%	1.06%	2.14%
2006.2	0.59%	0.91%	2.26%
2006.3	0.52%	0.81%	2.34%
2006.4	0.46%	0.78%	2.36%
2007.1	0.50%	0.76%	2.40%
2007.2	0.64%	0.79%	2.45%
2007.3	0.68%	0.87%	2.51%
2007.4	0.63%	1.02%	2.59%

Appendix 7 Change of the Share of GDP Component (1987-2007)

	Proportion of Real GDP (X_{it}/RGDP)			
Year	Consumption	Government Spending	Investment	Net Export
1987.1	63.17%	16.22%	23.22%	-2.61%
1987.2	62.74%	15.89%	23.31%	-1.94%
1987.3	62.32%	15.59%	23.41%	-1.33%
1987.4	61.86%	15.31%	23.59%	-0.76%
1988.1	62.38%	14.84%	23.79%	-1.01%
1988.2	62.85%	14.42%	23.96%	-1.24%
1988.3	63.22%	14.05%	24.17%	-1.44%
1988.4	63.57%	13.71%	24.34%	-1.62%
1989.1	62.87%	14.04%	24.65%	-1.55%
1989.2	63.38%	14.34%	23.77%	-1.49%
1989.3	63.86%	14.63%	22.94%	-1.43%
1989.4	64.31%	14.90%	22.15%	-1.37%
1990.1	63.78%	14.68%	21.95%	-0.40%
1990.2	63.27%	14.46%	21.75%	0.52%
1990.3	62.78%	14.26%	21.56%	1.40%
1990.4	62.31%	14.06%	21.39%	2.24%
1991.1	62.34%	13.84%	21.54%	2.28%
1991.2	62.36%	13.63%	21.69%	2.32%
1991.3	62.39%	13.44%	21.82%	2.35%
1991.4	62.41%	13.26%	21.95%	2.38%
1992.1	62.21%	12.81%	23.13%	1.86%
1992.2	62.03%	12.41%	24.18%	1.39%
1992.3	61.86%	12.05%	25.12%	0.97%
1992.4	61.72%	11.72%	25.98%	0.59%
1993.1	61.16%	11.52%	27.63%	-0.30%
1993.2	60.68%	11.34%	29.05%	-1.07%
1993.3	60.26%	11.19%	30.30%	-1.75%
1993.4	59.89%	11.05%	31.39%	-2.34%
1994.1	59.45%	10.67%	31.22%	-1.34%
1994.2	59.07%	10.34%	31.07%	-0.48%
1994.3	58.75%	10.06%	30.95%	0.24%
1994.4	58.47%	9.82%	30.84%	0.88%
1995.1	58.56%	9.74%	30.69%	1.00%
1995.2	58.65%	9.68%	30.56%	1.12%
1995.3	58.72%	9.62%	30.44%	1.22%
1995.4	58.79%	9.57%	30.33%	1.31%
1996.1	58.89%	9.30%	30.43%	1.38%
1996.2	58.99%	9.05%	30.53%	1.44%
1996.3	59.08%	8.82%	30.61%	1.49%

	Proportion of Real GDP			
Year	Consumption	Government Spending	Investment	Net Export
1996.4	59.16%	8.61%	30.69%	1.54%
1997.1	58.87%	8.66%	30.28%	2.18%
1997.2	58.60%	8.72%	29.89%	2.79%
1997.3	58.34%	8.77%	29.52%	3.37%
1997.4	58.09%	8.82%	29.17%	3.92%
1998.1	57.91%	8.89%	29.38%	3.82%
1998.2	57.73%	8.95%	29.59%	3.73%
1998.3	57.56%	9.01%	29.79%	3.64%
1998.4	57.39%	9.07%	29.99%	3.55%
1999.1	57.56%	9.49%	29.80%	3.15%
1999.2	57.71%	9.90%	29.63%	2.77%
1999.3	57.87%	10.29%	29.45%	2.39%
1999.4	58.01%	10.68%	29.29%	2.02%
2000.1	57.97%	10.99%	29.13%	1.90%
2000.2	57.93%	11.30%	28.99%	1.79%
2000.3	57.88%	11.58%	28.85%	1.68%
2000.4	57.85%	11.86%	28.72%	1.58%
2001.1	57.51%	12.13%	28.87%	1.49%
2001.2	57.20%	12.39%	29.01%	1.40%
2001.3	56.90%	12.63%	29.15%	1.32%
2001.4	56.62%	12.86%	29.28%	1.25%
2002.1	56.04%	12.96%	29.68%	1.33%
2002.2	55.49%	13.04%	30.06%	1.40%
2002.3	54.96%	13.13%	30.43%	1.48%
2002.4	54.46%	13.21%	30.78%	1.55%
2003.1	53.63%	13.03%	31.93%	1.42%
2003.2	52.84%	12.85%	33.00%	1.30%
2003.3	52.11%	12.69%	34.02%	1.18%
2003.4	51.41%	12.54%	34.97%	1.08%
2004.1	50.62%	12.38%	35.83%	1.17%
2004.2	49.90%	12.24%	36.61%	1.25%
2004.3	49.23%	12.11%	37.33%	1.33%
2004.4	48.61%	11.99%	38.00%	1.40%
2005.1	47.69%	11.55%	38.65%	2.10%
2005.2	46.84%	11.14%	39.26%	2.76%
2005.3	46.04%	10.76%	39.82%	3.38%
2005.4	45.29%	10.40%	40.35%	3.96%
2006.1	44.54%	10.05%	40.91%	4.50%
2006.2	43.84%	9.73%	41.43%	5.00%
2006.3	43.18%	9.43%	41.91%	5.48%
2006.4	42.57%	9.14%	42.37%	5.92%
2007.1	41.60%	9.10%	42.98%	6.31%

	Proportion of Real GDP			
Year	**Consumption**	**Government Spending**	**Investment**	**Net Export**
2007.2	40.72%	9.07%	43.55%	6.67%
2007.3	39.90%	9.03%	44.07%	7.00%
2007.4	39.15%	9.00%	44.55%	7.30%

Source: China Statistical Yearbook 2008.

Notes: The GDP deflator is used to calculate the real terms of the GDP components. Annual data are converted to quarterly data by adopting low to high frequency conversion option – linear-match last method in EViews program.

Appendix 8

Rolling Standard Deviation of GDP Components' Growth Rate (1989-2007)

	Rolling Standard Deviation of Growth Rate			
Year	**Consumption**	**Government Spending**	**Investment**	**Net Export**
1989.4	0.0411	0.0308	0.0889	0.6210
1990.1	0.0460	0.0299	0.1049	0.6285
1990.2	0.0482	0.0290	0.1082	0.7042
1990.3	0.0488	0.0281	0.1045	0.8649
1990.4	0.0475	0.0269	0.0974	1.1040
1991.1	0.0467	0.0266	0.0934	2.1609
1991.2	0.0447	0.0257	0.0893	2.5381
1991.3	0.0350	0.0257	0.0810	2.5603
1991.4	0.0332	0.0200	0.0822	2.5058
1992.1	0.0399	0.0209	0.0963	2.4798
1992.2	0.0441	0.0201	0.1155	2.4640
1992.3	0.0457	0.0204	0.1322	2.4539
1992.4	0.0453	0.0138	0.1420	2.4453
1993.1	0.0409	0.0168	0.1340	2.4458
1993.2	0.0373	0.0182	0.1311	2.4578
1993.3	0.0318	0.0180	0.1207	2.5065
1993.4	0.0293	0.0181	0.1197	2.7845
1994.1	0.0281	0.0283	0.1060	2.5044
1994.2	0.0300	0.0311	0.0965	2.1598
1994.3	0.0298	0.0312	0.0860	2.1081
1994.4	0.0302	0.0311	0.0865	2.0851
1995.1	0.0289	0.0300	0.0963	2.0731
1995.2	0.0286	0.0300	0.1082	2.1501
1995.3	0.0286	0.0300	0.1186	2.6958
1995.4	0.0272	0.0306	0.1199	2.7359
1996.1	0.0267	0.0272	0.1206	2.7629
1996.2	0.0260	0.0282	0.1089	2.7604
1996.3	0.0256	0.0308	0.0973	2.6728
1996.4	0.0250	0.0217	0.0520	2.1351
1997.1	0.0240	0.0224	0.0371	1.8435
1997.2	0.0196	0.0197	0.0357	1.8685
1997.3	0.0196	0.0236	0.0283	1.8685
1997.4	0.0257	0.0259	0.0353	1.8313
1998.1	0.0262	0.0305	0.0348	1.6860
1998.2	0.0274	0.0335	0.0346	1.0931
1998.3	0.0276	0.0373	0.0351	0.4594

	Rolling Standard Deviation of Growth Rate			
Year	**Consumption**	**Government Spending**	**Investment**	**Net Export**
1998.4	0.0274	0.0403	0.0367	0.5035
1999.1	0.0273	0.0458	0.0368	0.5473
1999.2	0.0277	0.0498	0.0371	0.5919
1999.3	0.0275	0.0532	0.0377	0.6371
1999.4	0.0220	0.0646	0.0320	0.6834
2000.1	0.0180	0.0709	0.0280	0.7089
2000.2	0.0177	0.0695	0.0279	0.6901
2000.3	0.0177	0.0666	0.0278	0.5941
2000.4	0.0138	0.0610	0.0209	0.3589
2001.1	0.0127	0.0563	0.0193	0.2249
2001.2	0.0114	0.0497	0.0194	0.1470
2001.3	0.0124	0.0444	0.0185	0.1014
2001.4	0.0138	0.0378	0.0156	0.0857
2002.1	0.0150	0.0370	0.0185	0.0958
2002.2	0.0159	0.0403	0.0229	0.1265
2002.3	0.0173	0.0449	0.0261	0.1630
2002.4	0.0169	0.0425	0.0291	0.1967
2003.1	0.0129	0.0380	0.0380	0.1933
2003.2	0.0128	0.0409	0.0434	0.1773
2003.3	0.0135	0.0459	0.0482	0.1676
2003.4	0.0135	0.0508	0.0529	0.1749
2004.1	0.0113	0.0508	0.0547	0.1719
2004.2	0.0090	0.0485	0.0536	0.1675
2004.3	0.0080	0.0454	0.0493	0.1708
2004.4	0.0076	0.0407	0.0434	0.1901
2005.1	0.0068	0.0371	0.0377	0.3075
2005.2	0.0061	0.0354	0.0321	0.4629
2005.3	0.0062	0.0364	0.0271	0.6224
2005.4	0.0068	0.0392	0.0229	0.7780
2006.1	0.0046	0.0377	0.0242	0.7974
2006.2	0.0054	0.0369	0.0248	0.7767
2006.3	0.0055	0.0369	0.0254	0.7306
2006.4	0.0054	0.0371	0.0225	0.6606
2007.1	0.0054	0.0349	0.0179	0.6006
2007.2	0.0053	0.0341	0.0125	0.5577
2007.3	0.0054	0.0368	0.0086	0.5381
2007.4	0.0062	0.0436	0.0070	0.5427

Appendix 9

Rolling Standard Deviation of GDP Components' Growth Contribution (1989-2007)

	Rolling Standard Deviation of Growth Contribution			
Year	**Consumption**	**Government Spending**	**Investment**	**Net Export**
1989.4	2.56%	0.47%	2.04%	2.02%
1990.1	2.86%	0.45%	2.44%	1.63%
1990.2	2.99%	0.43%	2.53%	1.31%
1990.3	3.02%	0.40%	2.46%	1.23%
1990.4	2.95%	0.38%	2.31%	1.43%
1991.1	2.90%	0.37%	2.22%	1.53%
1991.2	2.77%	0.36%	2.12%	1.55%
1991.3	2.17%	0.36%	1.91%	1.50%
1991.4	2.07%	0.27%	1.91%	1.37%
1992.1	2.48%	0.28%	2.17%	1.31%
1992.2	2.74%	0.27%	2.58%	1.36%
1992.3	2.83%	0.28%	2.94%	1.49%
1992.4	2.81%	0.19%	3.15%	1.68%
1993.1	2.53%	0.23%	2.99%	1.90%
1993.2	2.30%	0.24%	3.02%	2.07%
1993.3	1.96%	0.24%	2.88%	2.10%
1993.4	1.80%	0.34%	3.03%	1.91%
1994.1	1.75%	0.34%	2.72%	1.58%
1994.2	1.89%	0.38%	2.43%	1.39%
1994.3	1.86%	0.38%	2.09%	1.53%
1994.4	1.88%	0.38%	1.91%	1.93%
1995.1	1.78%	0.35%	2.03%	2.14%
1995.2	1.76%	0.35%	2.30%	2.23%
1995.3	1.76%	0.35%	2.62%	2.25%
1995.4	1.66%	0.35%	2.76%	2.21%
1996.1	1.64%	0.32%	2.85%	2.12%
1996.2	1.58%	0.32%	2.67%	1.94%
1996.3	1.57%	0.35%	2.46%	1.66%
1996.4	1.48%	0.22%	1.43%	1.14%
1997.1	1.44%	0.23%	1.10%	0.93%
1997.2	1.20%	0.19%	1.08%	0.92%
1997.3	1.18%	0.22%	0.88%	0.93%
1997.4	1.52%	0.23%	1.08%	0.80%
1998.1	1.54%	0.27%	1.06%	0.74%
1998.2	1.61%	0.29%	1.05%	0.73%
1998.3	1.62%	0.32%	1.06%	0.74%

	Rolling Standard Deviation of Growth Contribution			
Year	**Consumption**	**Government Spending**	**Investment**	**Net Export**
1998.4	1.61%	0.35%	1.10%	0.80%
1999.1	1.61%	0.40%	1.10%	0.89%
1999.2	1.63%	0.44%	1.11%	1.01%
1999.3	1.63%	0.48%	1.13%	1.15%
1999.4	1.29%	0.59%	0.95%	1.29%
2000.1	1.03%	0.67%	0.82%	1.36%
2000.2	1.00%	0.68%	0.81%	1.35%
2000.3	1.00%	0.66%	0.81%	1.23%
2000.4	0.78%	0.62%	0.60%	0.96%
2001.1	0.72%	0.58%	0.56%	0.70%
2001.2	0.64%	0.52%	0.56%	0.51%
2001.3	0.71%	0.44%	0.53%	0.39%
2001.4	0.79%	0.33%	0.44%	0.38%
2002.1	0.86%	0.26%	0.52%	0.41%
2002.2	0.92%	0.23%	0.64%	0.44%
2002.3	1.00%	0.27%	0.74%	0.46%
2002.4	0.98%	0.29%	0.84%	0.41%
2003.1	0.77%	0.29%	1.12%	0.35%
2003.2	0.77%	0.37%	1.31%	0.29%
2003.3	0.81%	0.46%	1.48%	0.25%
2003.4	0.82%	0.55%	1.67%	0.25%
2004.1	0.69%	0.57%	1.78%	0.24%
2004.2	0.56%	0.56%	1.80%	0.23%
2004.3	0.50%	0.54%	1.72%	0.23%
2004.4	0.47%	0.50%	1.56%	0.24%
2005.1	0.43%	0.47%	1.38%	0.37%
2005.2	0.39%	0.45%	1.17%	0.58%
2005.3	0.39%	0.47%	0.92%	0.81%
2005.4	0.41%	0.50%	0.59%	1.05%
2006.1	0.27%	0.47%	0.47%	1.19%
2006.2	0.29%	0.46%	0.37%	1.26%
2006.3	0.29%	0.45%	0.37%	1.25%
2006.4	0.28%	0.45%	0.35%	1.16%
2007.1	0.28%	0.42%	0.28%	1.05%
2007.2	0.24%	0.40%	0.28%	0.90%
2007.3	0.24%	0.40%	0.30%	0.72%
2007.4	0.29%	0.44%	0.33%	0.48%

Appendix 10

Volatilities of Components of Consumption (1989-2007)

	Rolling Standard Deviation of Growth Rate			Rolling Standard Deviation of Growth Contribution		
Year	Rural	Urban	Government	Rural	Urban	Government
1989.4	3.01%	4.67%	6.67%	0.86%	0.95%	0.86%
1990.1	3.45%	5.29%	6.95%	0.98%	1.08%	0.89%
1990.2	3.73%	5.68%	6.76%	1.05%	1.15%	0.87%
1990.3	3.88%	5.93%	6.44%	1.08%	1.20%	0.83%
1990.4	3.81%	5.99%	6.09%	1.06%	1.21%	0.78%
1991.1	3.77%	5.97%	6.05%	1.05%	1.21%	0.77%
1991.2	3.58%	5.71%	5.99%	0.99%	1.17%	0.75%
1991.3	2.75%	4.59%	5.15%	0.75%	0.96%	0.65%
1991.4	2.47%	3.71%	5.63%	0.65%	0.88%	0.69%
1992.1	2.85%	4.01%	6.74%	0.72%	1.05%	0.81%
1992.2	3.10%	4.44%	7.13%	0.77%	1.20%	0.86%
1992.3	3.34%	4.79%	6.59%	0.82%	1.30%	0.78%
1992.4	3.48%	4.89%	5.78%	0.85%	1.33%	0.68%
1993.1	3.30%	4.53%	4.87%	0.81%	1.24%	0.57%
1993.2	3.09%	4.30%	4.03%	0.75%	1.19%	0.47%
1993.3	2.77%	3.65%	4.06%	0.67%	1.02%	0.47%
1993.4	2.46%	3.35%	4.03%	0.59%	0.97%	0.47%
1994.1	2.30%	2.91%	5.16%	0.56%	0.83%	0.60%
1994.2	2.22%	2.88%	6.51%	0.56%	0.77%	0.75%
1994.3	2.60%	2.65%	6.54%	0.61%	0.70%	0.76%
1994.4	3.06%	2.62%	6.49%	0.67%	0.68%	0.75%
1995.1	3.34%	2.56%	5.87%	0.69%	0.68%	0.67%
1995.2	3.43%	2.64%	5.69%	0.70%	0.69%	0.65%
1995.3	3.44%	2.85%	5.50%	0.70%	0.75%	0.62%
1995.4	3.51%	2.78%	4.83%	0.70%	0.74%	0.53%
1996.1	3.40%	3.04%	4.83%	0.68%	0.80%	0.53%
1996.2	3.49%	3.19%	4.16%	0.69%	0.85%	0.45%
1996.3	3.17%	3.57%	4.14%	0.63%	0.95%	0.45%
1996.4	3.92%	2.87%	3.75%	0.78%	0.79%	0.36%
1997.1	3.38%	2.88%	4.51%	0.67%	0.79%	0.41%
1997.2	2.55%	3.02%	4.21%	0.50%	0.81%	0.36%
1997.3	3.08%	2.73%	4.33%	0.61%	0.73%	0.36%
1997.4	4.31%	2.75%	4.33%	0.86%	0.77%	0.36%
1998.1	4.97%	2.32%	4.47%	1.00%	0.66%	0.37%
1998.2	5.56%	2.06%	4.42%	1.12%	0.59%	0.36%
1998.3	5.95%	1.98%	4.14%	1.20%	0.57%	0.33%

	Rolling Standard Deviation of Growth Rate			Rolling Standard Deviation of Growth Contribution		
Year	Rural	Urban	Government	Rural	Urban	Government
1998.4	6.31%	1.66%	4.05%	1.27%	0.50%	0.32%
1999.1	6.46%	1.61%	3.82%	1.30%	0.50%	0.30%
1999.2	6.45%	1.61%	3.21%	1.30%	0.49%	0.25%
1999.3	6.10%	1.58%	2.50%	1.23%	0.49%	0.19%
1999.4	4.34%	1.62%	3.03%	0.89%	0.51%	0.25%
2000.1	2.69%	1.70%	3.49%	0.55%	0.55%	0.28%
2000.2	1.78%	1.72%	3.45%	0.35%	0.57%	0.28%
2000.3	1.29%	1.70%	3.35%	0.24%	0.56%	0.27%
2000.4	1.28%	1.21%	2.47%	0.23%	0.40%	0.20%
2001.1	1.37%	1.08%	2.22%	0.25%	0.34%	0.18%
2001.2	1.37%	1.10%	2.08%	0.24%	0.32%	0.17%
2001.3	1.37%	1.40%	2.34%	0.24%	0.40%	0.19%
2001.4	1.24%	1.70%	2.66%	0.22%	0.50%	0.21%
2002.1	1.08%	1.90%	2.91%	0.19%	0.56%	0.23%
2002.2	0.76%	2.07%	3.15%	0.14%	0.61%	0.25%
2002.3	0.58%	2.21%	3.38%	0.11%	0.66%	0.27%
2002.4	0.70%	2.12%	3.12%	0.13%	0.65%	0.24%
2003.1	0.69%	1.68%	2.27%	0.12%	0.52%	0.17%
2003.2	1.27%	1.47%	2.17%	0.20%	0.46%	0.18%
2003.3	1.81%	1.31%	2.27%	0.29%	0.42%	0.19%
2003.4	2.30%	1.07%	2.31%	0.35%	0.36%	0.19%
2004.1	2.35%	0.71%	2.04%	0.36%	0.24%	0.16%
2004.2	2.24%	0.43%	1.75%	0.34%	0.15%	0.15%
2004.3	2.12%	0.37%	1.73%	0.32%	0.12%	0.15%
2004.4	1.96%	0.40%	1.90%	0.29%	0.14%	0.15%
2005.1	1.84%	0.45%	1.96%	0.27%	0.16%	0.16%
2005.2	1.79%	0.55%	2.07%	0.26%	0.20%	0.16%
2005.3	1.80%	0.74%	2.33%	0.25%	0.26%	0.17%
2005.4	1.89%	0.93%	2.52%	0.26%	0.33%	0.18%
2006.1	2.03%	0.88%	2.29%	0.28%	0.31%	0.16%
2006.2	2.19%	0.88%	2.23%	0.29%	0.31%	0.15%
2006.3	2.07%	0.87%	2.26%	0.27%	0.30%	0.15%
2006.4	1.59%	0.84%	2.13%	0.20%	0.29%	0.14%
2007.1	1.26%	0.78%	1.98%	0.15%	0.26%	0.12%
2007.2	1.05%	0.72%	1.93%	0.12%	0.22%	0.10%
2007.3	0.81%	0.67%	2.39%	0.08%	0.19%	0.11%
2007.4	0.61%	0.68%	2.81%	0.06%	0.19%	0.13%

Appendix 11

Volatilities of Components of Investment (1989-2007)

	Rolling Standard Deviation of Growth Rate		Rolling Standard Deviation of Growth Contribution	
Year	Residential	Non Residential	Residential	Non Residential
1989.4	10.10%	9.61%	0.14%	2.14%
1990.1	11.53%	11.15%	0.14%	2.51%
1990.2	13.98%	11.42%	0.14%	2.57%
1990.3	17.31%	10.93%	0.15%	2.47%
1990.4	19.60%	10.18%	0.16%	2.32%
1991.1	20.68%	9.76%	0.16%	2.22%
1991.2	20.98%	9.33%	0.16%	2.11%
1991.3	20.22%	8.48%	0.16%	1.90%
1991.4	19.92%	8.52%	0.17%	1.87%
1992.1	17.96%	9.79%	0.22%	2.07%
1992.2	16.74%	11.50%	0.29%	2.40%
1992.3	17.72%	12.88%	0.37%	2.66%
1992.4	19.38%	13.47%	0.46%	2.74%
1993.1	20.40%	12.44%	0.51%	2.50%
1993.2	20.97%	12.01%	0.57%	2.46%
1993.3	19.67%	10.98%	0.58%	2.30%
1993.4	17.51%	11.06%	0.60%	2.43%
1994.1	14.99%	9.85%	0.54%	2.19%
1994.2	14.04%	9.02%	0.47%	1.97%
1994.3	13.59%	8.04%	0.39%	1.70%
1994.4	14.91%	8.08%	0.33%	1.60%
1995.1	16.81%	9.00%	0.31%	1.73%
1995.2	18.41%	10.14%	0.33%	1.97%
1995.3	19.17%	11.18%	0.38%	2.24%
1995.4	18.28%	11.37%	0.40%	2.36%
1996.1	17.62%	11.50%	0.41%	2.44%
1996.2	15.34%	10.44%	0.39%	2.29%
1996.3	13.22%	9.39%	0.35%	2.11%
1996.4	6.82%	5.08%	0.21%	1.23%
1997.1	4.49%	3.69%	0.17%	0.95%
1997.2	4.31%	3.53%	0.18%	0.92%
1997.3	3.69%	2.74%	0.17%	0.71%
1997.4	4.85%	3.33%	0.24%	0.84%
1998.1	4.91%	3.25%	0.25%	0.81%
1998.2	4.89%	3.23%	0.25%	0.80%
1998.3	4.91%	3.28%	0.26%	0.81%

	Rolling Standard Deviation of Growth Rate		Rolling Standard Deviation of Growth Contribution	
Year	Residential	Non Residential	Residential	Non Residential
1998.4	5.00%	3.42%	0.27%	0.83%
1999.1	4.98%	3.43%	0.27%	0.84%
1999.2	4.99%	3.46%	0.27%	0.85%
1999.3	4.98%	3.52%	0.27%	0.86%
1999.4	4.09%	2.99%	0.24%	0.72%
2000.1	3.54%	2.59%	0.22%	0.60%
2000.2	3.65%	2.58%	0.22%	0.60%
2000.3	3.90%	2.56%	0.23%	0.59%
2000.4	3.71%	1.83%	0.21%	0.42%
2001.1	3.83%	1.72%	0.21%	0.40%
2001.2	3.92%	1.81%	0.22%	0.41%
2001.3	3.61%	1.90%	0.20%	0.42%
2001.4	2.60%	1.94%	0.15%	0.41%
2002.1	1.90%	2.37%	0.12%	0.50%
2002.2	1.89%	2.75%	0.13%	0.58%
2002.3	2.18%	2.95%	0.16%	0.63%
2002.4	2.54%	3.13%	0.19%	0.67%
2003.1	3.33%	3.98%	0.25%	0.88%
2003.2	3.79%	4.53%	0.29%	1.02%
2003.3	4.07%	5.09%	0.32%	1.16%
2003.4	4.18%	5.69%	0.34%	1.33%
2004.1	4.16%	5.94%	0.35%	1.43%
2004.2	3.93%	5.86%	0.35%	1.46%
2004.3	3.43%	5.46%	0.32%	1.41%
2004.4	2.80%	4.88%	0.27%	1.29%
2005.1	2.29%	4.29%	0.23%	1.15%
2005.2	1.86%	3.72%	0.20%	0.99%
2005.3	1.50%	3.27%	0.18%	0.79%
2005.4	1.25%	2.98%	0.17%	0.57%
2006.1	1.37%	3.24%	0.20%	0.52%
2006.2	1.60%	3.41%	0.23%	0.49%
2006.3	1.70%	3.56%	0.25%	0.53%
2006.4	1.75%	3.29%	0.28%	0.53%
2007.1	1.78%	2.79%	0.29%	0.46%
2007.2	1.79%	2.16%	0.30%	0.37%
2007.3	1.67%	1.62%	0.27%	0.31%
2007.4	1.36%	1.23%	0.22%	0.29%