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Tara Sinclair
George Washington University

Yueqing Jia
George Washington University
World Bank

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Institute for International Economic Policy
1957 E St. NW, Suite 502
Voice: (202) 994-5320
Fax: (202) 994-5477
Email: iiep@gwu.edu
Web: www.gwu.edu/~iiep

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Yueqing Jia
Department of Economics
The George Washington University
and Development Economics Prospects Group
The World Bank
Washington, DC 20052

Tara Sinclair[1]
Department of Economics
and the Elliott School of International Affairs
The George Washington University
Washington, DC 20052

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1 Introduction

Although research on business cycles and economic growth has traditionally focused on developed countries, there is increasing interest in the economic fluctuations of developing countries. In particular, policymakers and researchers have focused on the growing importance of China, the largest developing country, within the global macroeconomic environment. Recent research by Jia and Sinclair (2009) suggests that China provides substantial information about the US business cycle. In particular, introducing information from the real GDP fluctuations of China increases the relative importance of transitory movements for US real GDP as compared to what is found using information from other countries. This paper extends that analysis to examine the relationships between the real GDP of China and that of developed countries more generally.

In terms of the discussion about China's modern role in the global economy, most of the focus has been placed on either China's connection with the US, given that they are the largest developing and developed economy respectively, or on China's connection with neighboring Asian and Pacific economies. Most research in terms of business cycle synchronization has focused mostly on the relationships of China with Asian and Pacific economies. These studies are based on regional economic integration and the discussion of the possibility of an Optimal Currency Area (OCA) for the region (Genberg, Liu and Jin, 2006). Trade has been recognized as the major determinant of the output fluctuation correlation of China with other East Asian and Pacific economies

(Sato and Zhang, 2006, Shin and Sohn, 2006). Beyond the region, Calderón (2007) finds increasing output co-movement of China's output fluctuation with Latin America countries along with the growing trade integration among the countries.

Much has also been made of the "special relationship" between China and the US, with terms such as "G-2" and "Chimerica" (Ferguson and Schularick 2007). China is, however, also tightly connected with developed countries other than the US. For example, although the US has been China's largest single country trade partner since the 1990s, Japan, South Korea, and Germany are also large trade partners with China. In total, developed countries comprise the majority of both China's export and import sources, but the US comprises less than 25%. According to the IMF direction of trade database, the US averaged only 20% of China's export market between 2000 and 2009, but the remaining six countries of the G7 were another 22% of China's export market and the remaining members of the developed OECD countries[2] were another 10% (OECD other countries account for 7%).

In terms of imports, the US on average supplies only 8% of China's imports, whereas the remaining countries of the G7 supply an additional 24% and the remaining developed OECD members another 7%. There is limited literature that addresses the output fluctuation correlations between China and developed countries. Fidrmuc and Batorova (2008), using quarterly CPI deflated GDP data from 1992-2006, analyze the dynamic correlations of China's business cycles with selected OECD countries under different cyclical frequencies. They find that despite the increasing trade and financial links between China and other

economies, China's business cycle behaves differently from most other economies. Non-European OECD countries such as the US, Korea, Australia, and Japan; which have more intensive economic linkage with China; show relatively high positive correlation of long run cycles (over 8 years) In general, the dynamic correlations tend to increase in more recent years. The US has a positive correlation with China in both long run cycles (over 8 years) and short run cycles (less than 1.5 years). Qing et al (2002) and Chen et al. (2004), using classical correlation techniques, document the business cycle correlations of China with the US, Japan, and select European developed countries and find positive weak correlation between the output fluctuations of the US and China, while the correlations between China and Japan and the European countries are negative. Zong (2007), using a VAR model on annual data of China's GDP, G7 countries aggregate GDP and China's FDI, reports that G7 GDP Granger-caused the fluctuation of China's FDI and China's GDP, while there is no evidence for an effect in the opposite direction. Lowe (2010) shows that the rolling correlation of real quarterly growth of China and Australia outpace the correlation between growth of the US and Australia since 2000. Fidrmuc and Korhonen (2010) show that business cycle correlations between China and developed countries are zero on average.

Given the increased emphasis on China's role in the global economy, it is important to investigate further the nature of the relationships between China and other developed countries. In particular, we focus on China's relationship with two different aggregate measures for developed economies, the G7 and the OECD.

The model employed in this paper is based on the two-series correlated unobserved components (UC) model employed in Jia and Sinclair (2009) which was applied to examine the relationships between China and the US. The model was developed in Sinclair (2009) as a two-series extension of the correlated unobserved component model proposed by Morley, Nelson and Zivot (2003, hereafter MNZ). Similar multivariate UC models have been applied to macroeconomic variables within single economies such as the US (Morley 2007, Sinclair 2009) and Canada (Basistha 2007) and for an aggregate of the euro-zone countries (Berger, forthcoming). The model has also been applied for a cross-country study of the real output fluctuations of the G7 countries (Mitra and Sinclair, forthcoming). The model specifically allows us to distinguish cross-country correlations driven by the relationships between permanent shocks, caused by real shocks such as changes in technology and economic and social institutions, from those between transitory or cyclical movements, caused by changes in aggregate demand or monetary shocks. The model also allows us to explore the role of information from the dynamics of each series in identifying fluctuations in the other series. The correlated unobserved components model applied in this paper does not require any prior transformation or detrending of the data and places fewer restrictions among the series than other models. In particular, our method combines the detrending and correlation estimation into a single stage which improves both the estimates of the trend and cycle as well as the estimates of the correlations. Furthermore, this model nests many of the

common detrending methods (Trimbur and Harvey, 2003) and is thus more general than most other methods.

We present two different estimates: one with quarterly real GDP data for China with aggregate real GDP for the G7 countries and the other with quarterly real GDP data for China with aggregate real GDP for the 25 OECD member countries. Both models are estimated with quarterly data from 1978 through 2009.[3] We also compare these estimates with those based on a univariate unobserved components model of Chinese real GDP as well as a trivariate model of the real output of China, the US, and Japan. To preview the results, we find that China has little connection with the developed world aggregate. We cannot reject that there is no cross-series correlation, and the estimates of the components for both China and the developed world aggregates are not substantially different from the findings based on univariate models. The results are similar whether we use the G7 or the OECD aggregate.

The structure of the rest of the paper is as following: Section 2 presents the econometric model and estimation method. Section 3 discusses the data used in this paper. Section 4 presents the results of the model estimation. Section 5 concludes.

2 Model

This paper applies a two-series correlated unobserved components model similar to Sinclair (2009) and Jia and Sinclair (2009) to distinguish the correlation of the permanent shocks to output of China from permanent shocks to aggregate developed country output (in one model measured as an aggregate of OECD

countries and in the other measured as an aggregate of the G7 countries), separately from the correlation of the transitory shocks. The model simultaneously decomposes each output series into a stochastic trend, or permanent component, and a stationary transitory component. The trend, or permanent component, is assumed to be a process of random walk with drift (Stock and Watson 1988) in order to capture the steady-state level or long term potential output of the economy. The transitory component, defined as real GDP deviations from the permanent trend, is assumed to be stationary following a second order autoregressive process, or AR (2). The two-series approach enables us to: 1) identify the correlation of the shocks to permanent and transitory components of real output for each series with information of dynamics of the other in order to examine the linkages of permanent shocks and transitory shocks between the two economies, and 2) obtain new estimates of the permanent and transitory components for each series using the information of the other series.

This model is general enough to be applied to cointegrated series, but it does not require cointegration or common trends. The model allows any amount of correlation between permanent shocks to the series, from zero correlation to a common trend. If the series do share a common trend, then cointegration can be imposed in this framework to improve the efficiency of the estimates (Morley, 2007). Johansen Cointegration tests were applied to our series for both models and we cannot reject the null of no cointegration allowing for a linear deterministic trend in our data. We thus do not impose cointegration.

It is important to note that the transitory component captures transitory deviations from the permanent or steady state level, which may be fundamentally different from the traditionally defined business cycle (Morley and Piger, forthcoming). The traditional business cycle is often isolated from the series with a filter such as the Hodrick-Prescott (HP) or Band-Pass (BP) filter. In this paper, we follow a more general definition of permanent and transitory components, which is associated with the Beveridge and Nelson (1981) decomposition and the Harvey (1985) and Clark (1987) unobserved components models. The permanent component, or the trend, follows a stochastic process (a random walk with drift in the model) rather than a fixed or pre-determined path. The transitory component is stationary and is defined as the deviation from the stochastic trend, rather than the alternative definition of a cycle that captures alternating phases. The notion is more general than the alternating phases definition in that it avoids any prior determination of appropriate business cycle frequencies. This is particularly important for macroeconomic fluctuations of developing countries such as China, which may not experience typical traditional business cycle fluctuations. Under the "deviation from trend" definition, the permanent and transitory components of the economic fluctuations can be directly formulated in structural time series models (Harvey, 1993), cast in state space form, and estimated using the Kalman filter for maximum likelihood estimation (MLE) of the parameters using prediction error decomposition.

The measurement equation of our model is:

$$y_{it} = \tau_{it} + c_{it}, \tag{1}$$

where τ_{it} is the unobserved trend component and c_{it} is the unobserved cycle component for series i (where $i=DW$ represents the real GDP aggregate for the developed world and $i = C$ represents real GDP for China).

The transition equations are:

$$\tau_{it} = u_i + \tau_{it-1} + \eta_{it}, \tag{2}$$

$$c_{it} = \phi_{1i} c_{it-1} + \phi_{2i} c_{it-2} + \varepsilon_{it}, \tag{3}$$

where η_{it} and ε_{it} are assumed to be normally distributed with mean zero. There are no restrictions on the correlations between any of the contemporaneous shocks, i.e. no restrictions are imposed on the variance-covariance matrix, which allows us to estimate all potential contemporaneous correlations within and across series. The variance-covariance matrix is:

$$\Sigma = \begin{bmatrix} \sigma^2_{\eta_{DW}} & \sigma_{\eta_{DW}\eta_c} & \sigma_{\eta_{DW}\varepsilon_{DW}} & \sigma_{\eta_{DW}\varepsilon_c} \\ \sigma_{\eta_{DW}\eta_c} & \sigma^2_{\eta_c} & \sigma_{\eta_c\varepsilon_{DW}} & \sigma_{\eta_c\varepsilon_c} \\ \sigma_{\eta_{DW}\varepsilon_{DW}} & \sigma_{\eta_c\varepsilon_{DW}} & \sigma^2_{\varepsilon_{DW}} & \sigma_{\varepsilon_{DW}\varepsilon_c} \\ \sigma_{\eta_{DW}\varepsilon_c} & \sigma_{\eta_c\varepsilon_c} & \sigma_{\varepsilon_{DW}\varepsilon_c} & \sigma^2_{\varepsilon_c} \end{bmatrix} \tag{4}$$

We cast equations (1)-(3) into state space form and estimate the unobserved components and the parameters of the model using the Kalman filter and maximum likelihood in GAUSS. The unobserved components are estimated with the Kalman smoothing algorithm, which uses information from the whole sample period, i.e. the future data as well as the past data.[4]

3 Data

The model is estimated with quarterly real GDP data for China and a developed country aggregate from 1978 through 2009. The Chinese data are from the National Bureau of Statistics of China (NBS), the nation's statistical

authority.[5] Our study focuses on the real output fluctuations since 1978, when China embarked on the market-oriented and openness economic reform. Our data include the most recent official revisions for 2005 through 2009 based on the information collected through the second economic census completed at the end of 2009. For quarterly real GDP before 1992, when quarterly real GDP data were not published officially, the data are disaggregated from annual data using the Chow-Lin (1971) related series method based on Abeysinghe and Rajaguru (2004).[6] Their disaggregation uses money supply and international trade data, both available at the quarterly frequency, as related series. Abeysinghe and Rajaguru estimate the quarterly growth rates of real GDP for 1978 through 1994 based on the estimated relationship of annual real GDP growth rates and the related series from 1978 through 1996.[7] The results of the disaggregation are tested by the authors through model fitting and out-of-sample forecast evaluation. The Abeysinghe and Rajaguru estimates are the only published estimates of quarterly real GDP data for China for this period. The data allow us to investigate the relationship of Chinese economy with developed world since it started to integrate with the world economy. This longer time series provides more information on China's macro-economic fluctuations and improves the efficiency of the estimation. To investigate the possible irregularity caused by the difference of data sources and the robustness of the result, the model was also estimated with official Chinese real output data from 1992 through 2009. We find that the results are remarkably similar to the full sample results.

The Chinese real output data are seasonally adjusted using the X-12 ARIMA method. The X-12 ARIMA (2, 1, 2) and Tramo/seat (Time series Regression with ARIMA noise, Missing Values and Outliers/Signal Extraction in ARIMA Time series) methods give similar results. The finding is consistent with Blades (2007), who performed similar tests on current price quarterly GDP of China. The seasonal pattern of China's quarterly real GDP is regular and predictable. The method is consistent with the one applied by the OECD for the developed world data.

For the developed countries data, we focus on two measures: real GDP for the G7 countries and real GDP for 25 OECD countries (although a model of 30 OECD countries yielded equivalent results). The data come from the OECD and are measured as millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted.[8] The 25 OECD countries included in the OECD aggregate are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States (the 30-country aggregate adds the Czech Republic, Hungary, Korea, Poland, and the Slovak Republic).[9] The G7 countries are Canada, France, Germany, Italy, Japan, United Kingdom, and United States. It is important to note that all of the G7 countries are also included in the OECD aggregate.

3.1 Chinese Data Quality

Along with the increasing interest in China's economic performance, the quality of Chinese official macroeconomic statistics, including the GDP data,[10] has been repeatedly questioned by a number of researchers and media reports. Despite the efforts made by NBS to explain and improve the GDP estimates over years, confidence in the accuracy of official data is still low. The data quality still remains a problem that must be addressed for empirical research on Chinese macroeconomic issues.

In the early 2000s, heated discussions on the quality of Chinese macro data generated a large number of publications on this issue. The criticisms of China's official data are based on evidence from alternative GDP calculations (Maddison, 1998; Wu, 2000; Young, 2003), comparison with energy and transportation consumption data (Rawski, 2001), and suspects of data falsifications, especially on the local level, under the non-democratic political system.[11] In the media, people are also concerned about the quick publication, only two weeks after the end of reporting periods, of the preliminary national account data for such a big economy.[12] This criticism persists even though before 1988 the Bureau of Economic Analysis released real GDP estimates for the US just 15 days after the end of the quarter (Young, 1993).

Refutations to the criticisms show the alternative data series constructed or corrected by researchers have not been proved to be more precise or reliable (Holz, 2006). Many researchers find that GDP data problems are unlikely to be unique to China and the evidence is not robust for a conclusion of data manipulation or systematic data falsification (Holz, 2005 and 2006; Chow, 2006;

Klein and Ozmucur, 2003). Chinese statistical authorities explain most of the questions as lack of understanding of China's transitional statistic system and the nature of the transitional economy. Some problems have gained acknowledgement from the authorities (Xu, 2002 and Xu, 2004) and efforts have been made to improve the data quality. The data are compiled and revised based on the information gained from recently established regular surveys and economic censuses, revised financial statement reports for enterprises and the more sophisticated data sources system. Manipulating statistics to meet political objectives, as the most usual concerns, are much harder at the national level. Xu Gao of the World Bank provides evidence of the consistency of data from different government institutes for recent years in his official blog.[13]

After carefully reviewing the literature on Chinese data quality and their national accounting system, and comparing different data resources and data construction methods, we agree with many researchers and most international organizations (OECD, IMF[14]) that although there are weaknesses or short-comings in the statistical system that provides Chinese national accounts estimation, the Chinese official macroeconomic data after 1978 are not proved to be politically manipulated or systematically biased. The official data can serve as "a reliable guide" to the level and growth pattern of GDP, even though the margins of error are "certainly larger than that of the most developed countries" (Lequiller and Blades, 2006).

4 Results

Table 1 presents the classical correlations of the Hodrick-Prescott (1997) and Baxter-King (1999) cycles and the growth rates of real GDP of China with the G7 and the OECD aggregates over the entire sample period.[15] Note that the correlations of Hodrick-Prescott and the Baxter-King cycles may be due to spurious cycles generated by the detrending methods (Cogley and Nason, 1995, and Murray, 2003). Compared with the correlations between the US and China as reported in Jia and Sinclair (2009), the pattern is similar but in all cases the correlations are lower between the G7 and the OECD with China than between the US and China. Depending on the choice of method to address the nonstationarity that is present in the real GDP series the conclusion about the tightness of the relationship between China and the developed world differs substantially. In general it appears that China and the developed world share somewhere between less than 10% and over a quarter of their fluctuations. This lack of clear conclusion suggests that further investigation is warranted.

4.1 Correlated Unobserved Components Model Parameter Estimates

Tables 2 – 5 report the parameters of the maximum likelihood estimation of our two correlated unobserved components models for the entire sample period. The results are strikingly similar for China when we use either aggregate, although the standard errors suggest that the results based on the larger OECD aggregate are more precisely estimated than for the model using the G7 aggregate. The estimates for both aggregates are similar as well, and are consistent with estimates for developed countries individually, such as those reported in MNZ for the US and in Mitra and Sinclair (forthcoming) for the G-7 countries.

4.1.1 Drift Terms

Since each series is in logs and multiplied by 100, the estimated drift term multiplied by 4 can be interpreted as the average annual growth of the permanent component. According to our estimates, China's average permanent real growth rate is 9.6% annually whereas for the G7 it is 2.2% and for the OECD it is 2.3%. These estimates are similar to other estimates reported in the literature.

4.1.2 Autoregressive Parameters

The estimated autoregressive coefficients, which reflect the dynamics of the transitory components, are similar across the different models. The sum of the autoregressive coefficients, which provides a measure of persistence of the transitory components, suggests that China has a more persistent transitory component than either the G7 or the OECD aggregate. Both the G7 and the OECD have persistence measures less than 0.5, whereas for China it is 0.83.

4.1.3 Permanent and Transitory Standard Deviations

Presented in Table 3, the estimated standard deviations of the permanent and transitory shocks are similar across models. The standard deviation of the permanent shocks is larger than the standard deviation of the transitory shocks for both China and the developed country aggregate for both models. The result implies that the trend or permanent component for each series is much more variable than the traditional HP and BP smoothed trends. Furthermore, permanent shocks are relatively more important than the transitory shocks for each series. Permanent shocks to Chinese real GDP are substantially more variable than permanent shocks to the developed aggregates. Chinese permanent shocks have

almost twice the standard deviation of the developed world permanent shocks. For the transitory components, the difference is even more dramatic, with transitory shocks for China having almost three times the standard deviation as transitory shocks to the developed world. Thus, although the absolute magnitudes of both the transitory and the permanent standard deviations are higher for China than for the developed world aggregates, the ratio of permanent to transitory variability is less for China than the developed world aggregates. In both cases they are greater than one, however, suggesting an important role for permanent shocks for all series. It is possible in our case to have both more variable permanent components and more variable transitory components, because allowing for correlation opens up the possibility that there may be offsetting movements between the two components (if the correlation is negative, as we find for all series in our study, discussed further below).

4.1.4 Within Series Correlations

Based on our two-series correlated UC model, the correlations between the permanent and transitory shocks within the economies of China and the developed world are all significantly negative (Table 4). In fact the correlation of permanent and transitory shocks for all series is nearly perfectly negative based on both models. Negatively correlated permanent and transitory shocks are a common finding for real GDP. These results are consistent with prior research that has examined the correlation between permanent and transitory shocks for the real GDP of the U.S. (MNZ; Sinclair, 2009), Canada (Basistha, 2007), the U.S. and the U.K. (Nagakura, 2008), and the G-7 countries (Nagakura, 2007; Mitra and

Sinclair, forthcoming). The negative correlation has been interpreted as due to slow adjustment of the actual output of the economy to the permanent shocks to output. As Stock and Watson (1988) and MNZ (2003) explained, strong negative correlation of the permanent shocks with the transitory shocks implies that the economic fluctuations are driven mainly by permanent shocks, while the permanent shocks immediately shift the long term path of the output, the short run movements may include adjustments toward the shifted trend.

4.1.5 Cross Series Correlations

Table 5 shows the estimates of the correlations of the permanent-permanent shocks, the transitory –transitory shocks cross country and the permanent-transitory cross-correlations. The correlations are estimated simultaneously with the components. We find that for the G7 aggregate we cannot reject the null that there is no cross-series correlation. A likelihood ratio test with four restrictions results in a chi-squared statistic of 3.45 which has p-value of 0.49. Similarly, for the OECD aggregate, the likelihood ratio test statistic is 4.51 with a p-value of 0.34. This finding is consistent with the finding of Fidrmuc and Korhonen (2010) that business cycle correlations between China and developed countries are zero on average.

4.2 Estimated Permanent and Transitory Components

Figure 1 shows the estimated permanent and transitory components of the real GDP of China based on our two different bivariate models as well as the estimated components for the G7 and the OECD aggregates. These estimates suggest that the transitory components for the developed-world aggregates are

small and noisy, similar to previous findings for estimates of the developed countries individually (for example see Mitra and Sinclair, forthcoming, for the G7 countries). The permanent components appear very similar to the series themselves. For China, however, there appears to be more substantial transitory movement. Some of this more substantial transitory movement is simply due to the larger size of fluctuations more generally as compared to the developed countries. Recall from Section 4.1.3 that the transitory fluctuations for China are almost three times as variable as those of the developed world. The permanent component for Chinese real GDP still appears quite similar to the series itself.

The role of the information of the other countries is presented in the estimated transitory components in Figures 2 and 3. In Figure 2 we compare the estimated transitory component from two different models – the bivariate model with China and a developed country aggregate (the G7 and the OECD aggregate provide cycle estimates for China that are indistinguishable from each other) and the univariate correlated UC model applied to China alone. We see that the estimated components are broadly similar. Figure 3 shows that separating out two of the key members of the G7, i.e. the US and Japan, to create a trivariate model does not substantially change the estimated transitory component for China either. We also estimated a model with a larger OECD aggregate which included the real GDP of 30 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway,

Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. The results were unchanged.

Sinclair and Jia (2009) showed that adding information from US economic fluctuations does not visibly change the amplitudes and movement pattern of the transitory component of China as compared to the univariate results. They further show that adding other alternative external information sets such as the real GDP of Hong Kong or the oil price does not change this result. Here we show that even a large aggregate of developed world GDP provides little new information for China's real output fluctuations. Possible interpretations for the stability of China's transitory components across different bivariate models could be: first, most of the external shocks are permanent shocks to China which are not forecastable and thus do not change the transitory components; secondly, domestic factors such as domestic demand or monetary policy may be the major sources of China's real GDP fluctuations,[16] thus external information sets do not provide much forecasting information; thirdly, China's macroeconomic controls or adjustment policies could have largely isolated the external shocks from greatly influencing the macroeconomic performance of the country.

4.3 The "Great Recession"

From 2007 through 2009 most of the world experienced the "Great Recession." Although China did not experience an absolute decline in real GDP, according to most sources, including the Economic Cycle Research Institute (ECRI),[17] China experienced a growth cycle peak in May of 2007 and a trough in December of 2009. Similarly, the G7 and OECD countries all experienced

business cycle peaks and troughs during this period. Therefore, we next investigate what the model suggests about this important episode in our sample. Figure 4 presents a "zoom-in" on Chinese real GDP and our estimates for the permanent component based on three different models for the period 2007-2009. The estimates show that, although the estimates are broadly similar, if we relied on a univariate model to estimate the permanent component for China that we would assume that the permanent component moved substantially below the series between the second quarter of 2007 and the third quarter of 2008. According to the bivariate model, however, the permanent component remained much closer to the series. By contrast, the estimates for both the G7 and the OECD aggregates suggest that there was substantial downward movement in their permanent components during this recession (Figure 5).[18]

4 Conclusion

In this paper, we presented the estimates of two different bivariate correlated UC models for the real GDP of China with aggregate measures of developed country real GDP with quarterly data from 1978 through 2009: one with a G7 country aggregate and one with an OECD country aggregate. Our model permits us to examine both the within-country long term and short term properties of the output fluctuations of the two series and the cross-series relationships of the two series simultaneously. The estimation results also reveal the relative importance of permanent versus transitory movements in the relationship. We find that although China and the developed world share substantial trade connections, we cannot reject that there are no cross-series

correlations between Chinese real GDP and an aggregate of developed world GDP measured by either the G7 countries or the OECD countries.

Although there seems to be little correlation between the real output fluctuations of China and the developed world in terms of the permanent and transitory shocks and also little evidence of additional information for each other's fluctuations, there remain interesting similarities between China and the developed world. Like the findings for both individual developed countries reported in the literature as well as for the developed country aggregates reported here, we find that China has significant negative correlation between permanent and transitory shocks to its real GDP. We also find that China has an important role for permanent shocks in its real GDP fluctuations, which is similar to the finding for the developed countries. China does, however, have a much larger drift term, such that permanent shocks are substantially larger on average. These larger permanent shocks drive China's faster growth rate. Also for Chinese real GDP, both the permanent and transitory shocks are substantially more variable than those to developed countries. The similarities suggest that similar macroeconomic policies may be appropriate for China as for developed countries, although the lack of correlation and the greater size and variability of shocks may mean that different timing and size of policy may be necessary. The small correlation of China's output fluctuations with the developed world indicates that domestic factors such as economic reforms, domestic demand, and economic policies may be the major drivers of China's macro economic fluctuations.

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Table 1:
Correlations of Cycles for China and the Developed Country Aggregates [19]

Developed Country Aggregate	Quarterly Growth Rates	Year-on-Year Growth Rates	Hodrick Prescott Cycles (lamda=1600)	Baxter-King Cycles (cycle periods 6-32)
G7	0.09	0.18	0.28	0.21
OECD	0.11	0.16	0.24	0.14

Table 2. Estimation Results

	China and G7		China and OECD	
Log Likelihood:	-251.16		-247.13	
	China (SE)	**G7 (SE)**	**China (SE)**	**OECD (SE)**
Drift	2.40 (0.18)	0.56 (0.09)	2.39 (0.18)	0.58 (0.09)
phi1	1.31 (0.04)	0.56 (0.25)	1.31 (0.05)	0.56 (0.15)
phi2	-0.48 (0.04)	-0.07 (0.20)	-0.48 (0.05)	-0.10 (0.17)

Table 3. Standard Deviations of Shocks

	China and G7	China and OECD
Developed Permanent	1.04 (0.68)	0.99 (0.05)
China Permanent	1.97 (0.96)	1.97 (0.08)
Developed Transitory	0.59 (0.61)	0.62 (0.08)
China Transitory	1.43 (0.09)	1.43 (0.03)
Developed Ratio Perm/Trans	1.76	1.60
China Ratio Perm/Trans	1.38	1.38

Table 4. Within Series Correlations of Shocks

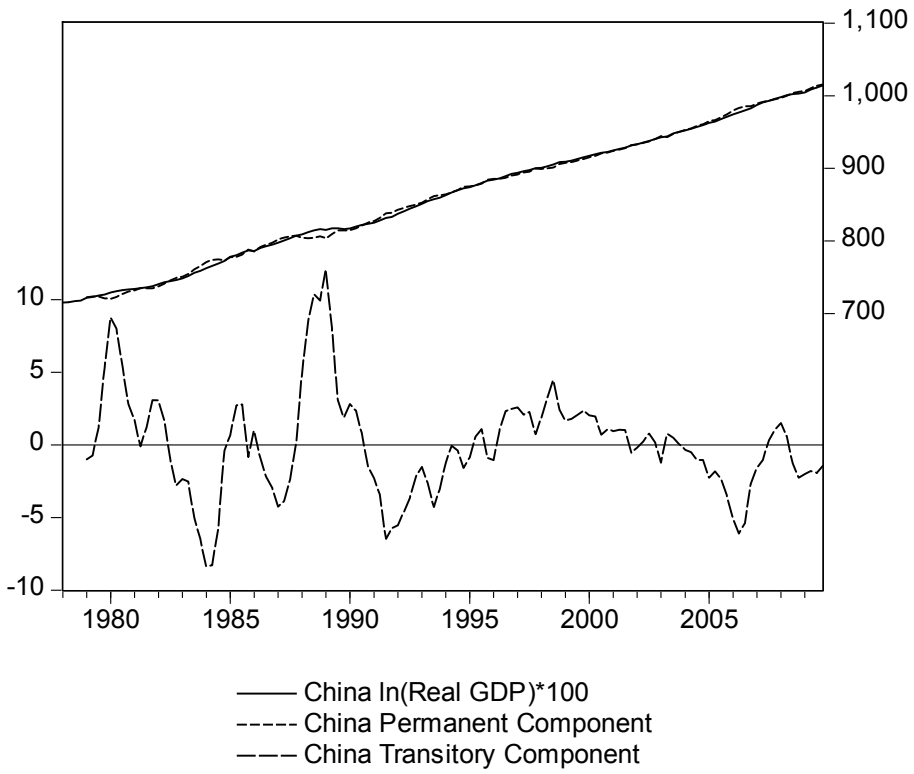
	China and G7	China and OECD
Permanent Developed with Transitory Developed	-0.99 (0.03)	-0.97 (0.02)
Permanent China with Transitory China	-0.99 (<0.01)	-0.99 (0.01)

Table 5. Cross Series Correlations of Shocks

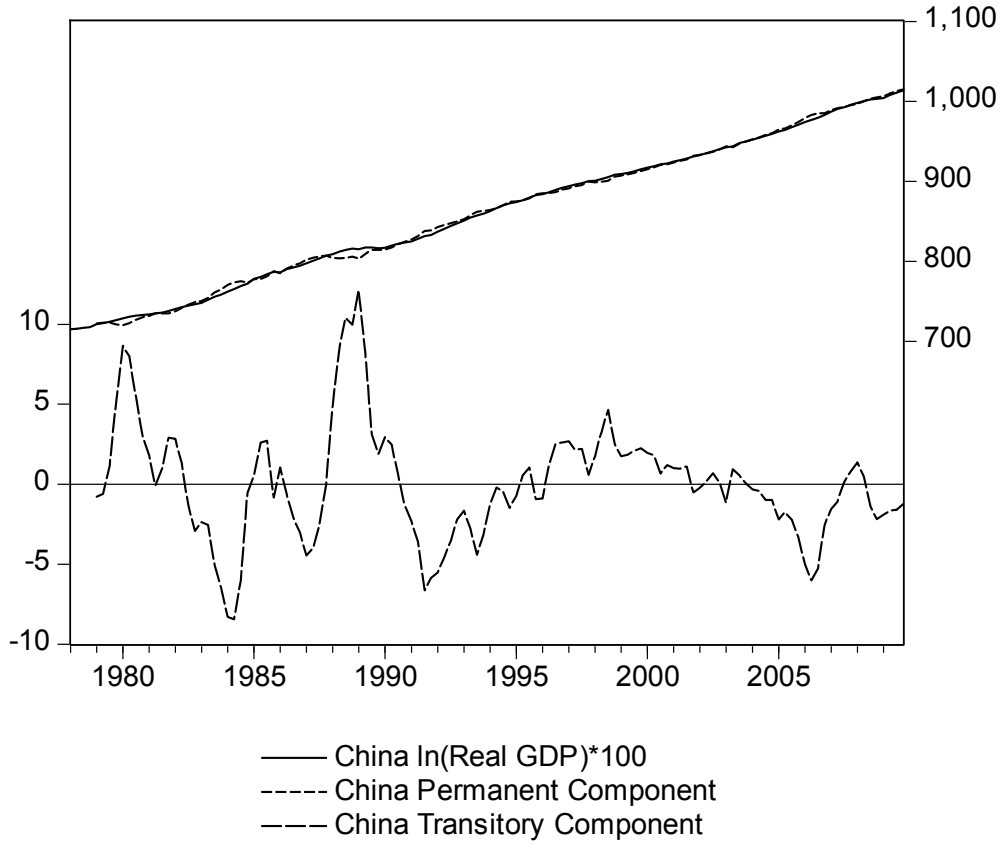
	G7	OECD
Permanent China with Permanent Developed	0.07 (0.17)	0.07 (0.04)
Transitory China with Transitory Developed	0.03 (<0.01)	-0.02 (0.01)
Permanent Developed with Transitory China	0.07 (0.19)	0.07 (<0.01)
Permanent China with Transitory Developed	-0.16 (0.02)	-0.11 (0.06)

Figure 1: Estimated permanent and transitory components.

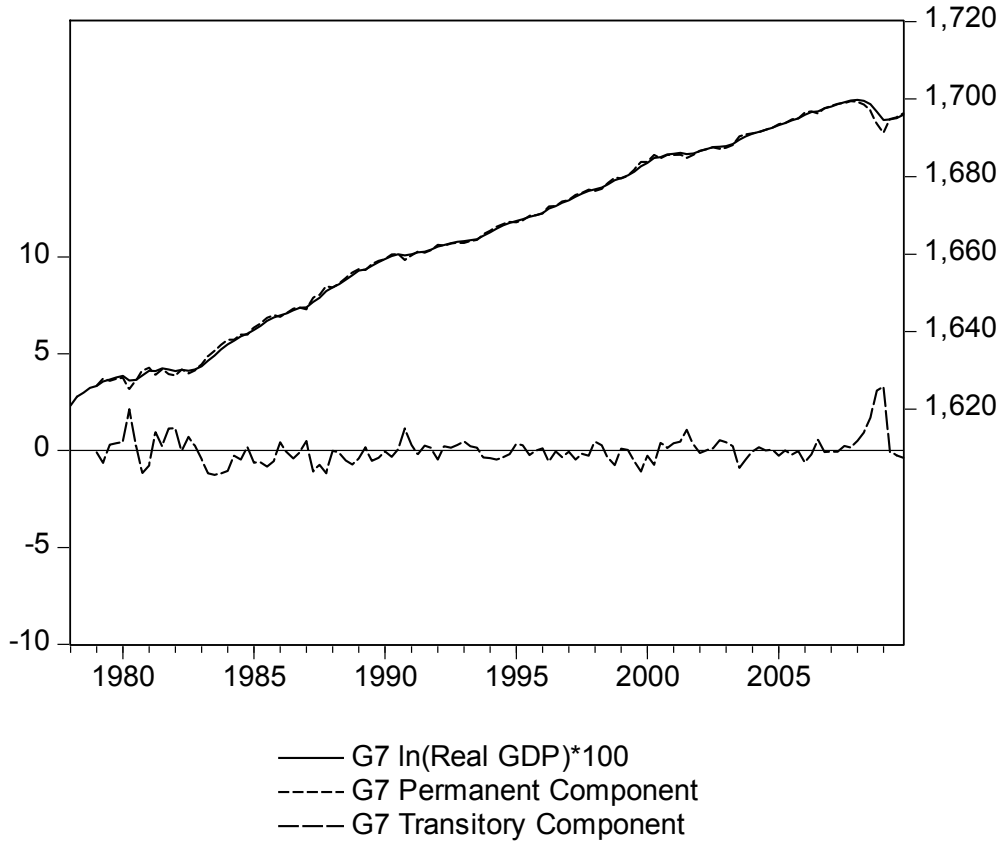
China Based on Bivariate Model with G7



China Based on Bivariate Model with OECD



G7 Based on Bivariate Model with China



OECD Based on Bivariate Model with China

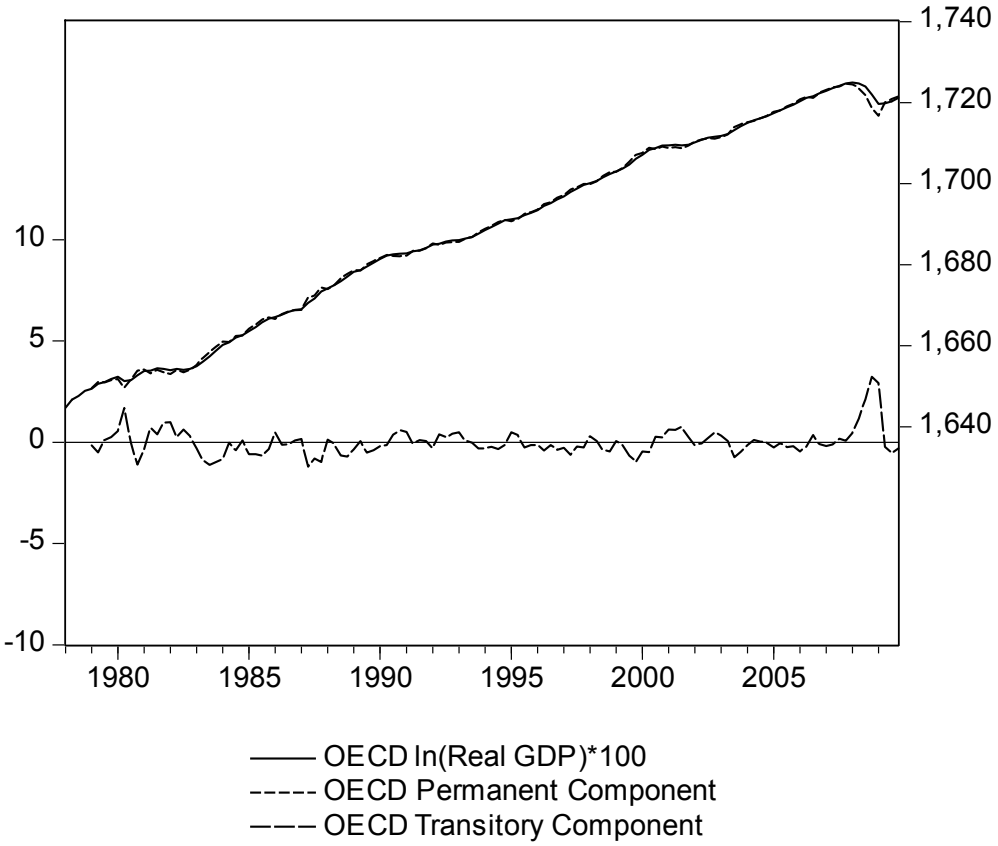


Figure 2: Comparing the Different Filtered Cycle Estimates

Univariate versus Bivariate

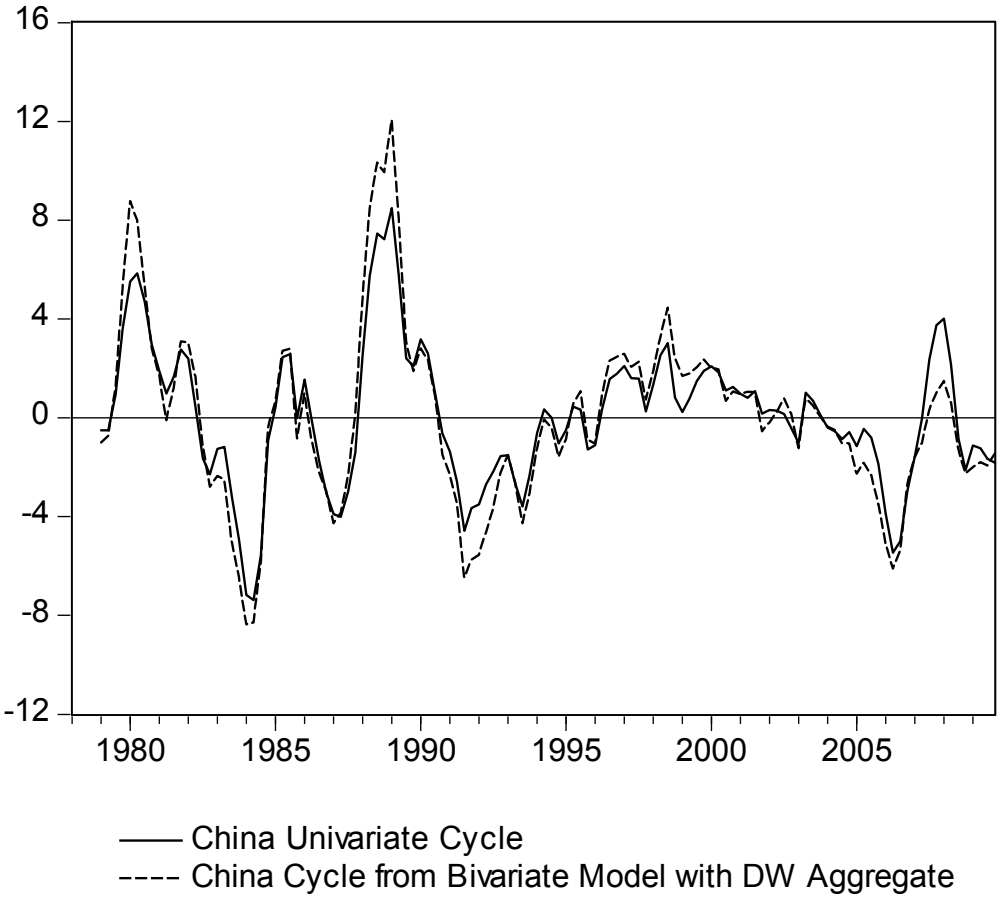


Figure 3: Comparing the Different Cycle Estimates

Univariate, Bivariate, and Trivariate Models

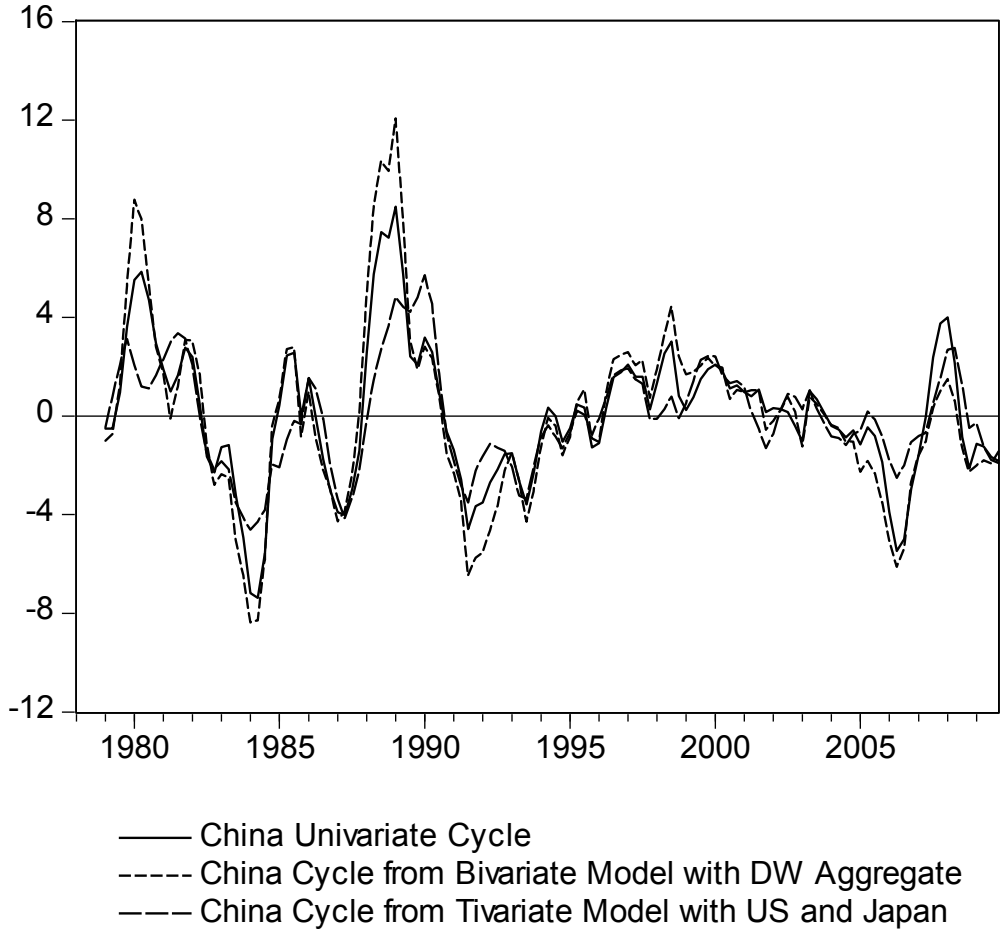


Figure 4: 2007 – 2009 Chinese Real GDP

and Permanent Component Estimates

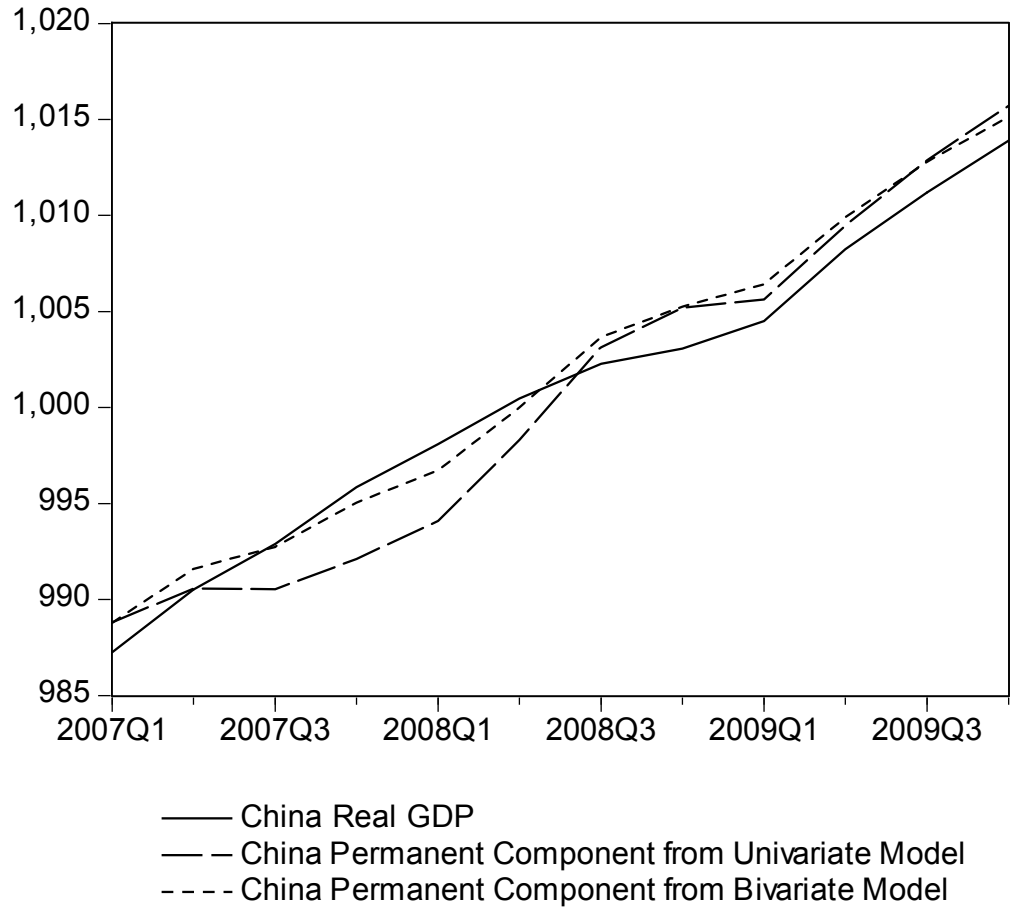
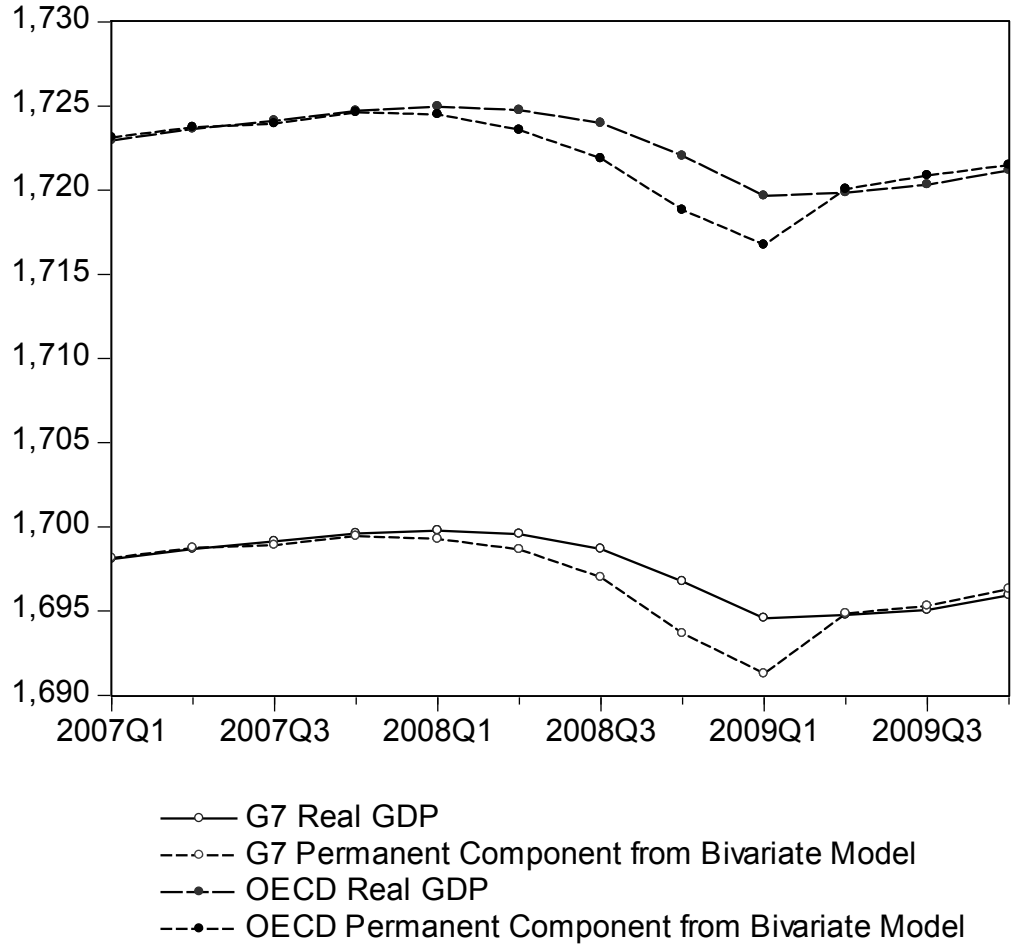


Figure 5: 2007 – 2009 G7 and OECD Real GDP

and Permanent Component Estimates



1 Corresponding author, email: tsinc@gwu.edu. The authors gratefully acknowledge support from GW-CIBER and the Institute for International Economic Policy (IIEP) of the Elliott School at GWU. We thank Deanna Jensen for excellent research assistance. We also thank Jinzhao Chen, Yin-Wong Cheung, Menzie Chinn, Jakob de Haan, James Morley, Tom Rawski, James Reade, Alessandro Rebucci, Bruce Reynolds, and Stephen Smith for helpful comments and discussions. The views in this paper are those of the authors and do not necessarily represent those of the institutes.

2 The developed OECD countries include the 25 OECD members in the aggregate data: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The developing OECD members include: the Czech Republic, Hungary, Korea, Poland, the Slovak Republic, and Mexico. The data do not include Chile, Slovenia and Israel, new members that joined the OECD after May of 2010.

3 We also estimated two additional models for robustness. One was a model for a 30-country OECD aggregate. The other was for a subsample from 1992-2009 to consider only the officially reported quarterly real GDP for China. The estimates were both quantitatively and qualitatively similar to those reported in this chapter. These estimates are available from the authors upon request.

4 The smoother does produce different estimates of the components as compared to the filter, particularly for Chinese real GDP. The cycle based on the smoothed estimates is substantially larger. Results for the filtered estimates are available from the authors upon request.

5 The official data are published as cumulated year on year growth rate at comparable price. Data from 1992-2005 are from the publication of National Bureau of Statistics of China: Historical Data on China Quarterly GDP Estimator 1992-2005, 2/2008 China Statistics Press ISBN/ISSN 9787503753565

6 The year 2000 is chosen as the base year because the inflation rate (CPI inflation) was close to zero during that year, which will minimize the distortion from inflation on the quarterly data within the base year.

7 We only use Abeysinghe and Rajaguru's data through 1991 and then use the NBS data.

8 The data were extracted on September 29, 2010 from OECD.Stat.

9 The 30-country aggregate was the largest available OECD aggregate at the time of the writing of this chapter. According to OECD.stat, "Chile became a member of the OECD on 7 May 2010, Slovenia on 21 July 2010 and Israel on 7 September 2010 and data for them now appears in the list of OECD member countries. Nevertheless, Chile, Israel and Slovenia have not yet been included in OECD area aggregation in the quarterly national accounts database for technical and timing reasons." The estimates using the 30-country aggregate are available from the authors upon request.

10 The *Economist* (2008) cited Goldman Sachs' ranking of the reliability of Chinese statistics from high to low as: Foreign trade, Money supply, Industrial production, consumer prices, GDP, retail sales, fixed investment, Employment, Average earnings, Unemployment, where GDP is in the middle.

11 See Holz (2006) for a detailed survey of the literature.

12 The most recent official announcement on the timing of revisions of the quarterly data has become more cautious and leaves more time for the first and final revisions of the number.

13 http://blogs.worldbank.org/eastasiapacific/are-chinese-statistics-manipulated

14 The World Bank criticized the Chinese national account statistics and revised their GDP estimation for China upward for 34% from the officially reported number in 1993. In 1996, the World Bank accepted China's reformed statistical system and the official GDP number again. But the World Bank revision and method of estimation are also questioned by many researchers.

15 The quarterly growth rate is defined as the first difference of the log of real GDP. The year-on-year growth rate is defined as log changes from the same quarter of the previous year, which is often used by articles published in Chinese, i.e. $y_t = \log(realGDP) \times 100$ Year on year growth rates $g_t = y_t - y_{t-4}$.

16 We do not consider domestic information sets because: first, availability of quarterly data of domestic economic indicators for our sample period are very limited, and second, the data construction of the data before 2000 has used the total international trade and money supply--the only quarterly series available.

17 www.businesscycle.com

18 Comparing the smoothed estimates reported here with the filtered estimates (available from the authors upon request) does suggest that hindsight improves our understanding of the role of permanent versus transitory shocks particularly for China in this episode. The filtered estimates suggest a much larger drop in the permanent component for China (more similar to the estimates reported for the developed country aggregates) as compared to the smoothed estimates.

19 The quarterly growth rate is defined as the first difference of the log of real GDP. The year-on-year growth rate is defined as log changes from the same quarter of the previous year, which is often used by articles published in Chinese, i.e. $y_t = \log(realGDP) \times 100$ Year on year growth rates $g_t = y_t - y_{t-4}$.